JOURNAL

OF THE

ROYAL MICROSCOPICAL SOCIETY;

CONTAINING ITS

TRANSACTIONS & PROCEEDINGS,

WITH OTHER

MICROSCOPICAL INFORMATION.

VOL. I.

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PREFACE.

In completing the first volume of the Society's Journal, the Publication Committee venture to regard with some satisfaction the new arrangement under which it has been issued, not so much, however, in respect to what has been actually accomplished, as on account of the organization they have been able to establish for the future, and which has been partially brought into operation in the later numbers of the Journal.

The Journal will be published bi-monthly, in February, April, June, August, October, and December; and whilst it will vary in size according to convenience, an endeavour will be made to ensure that it shall not contain less than sixty-four pages and two plates, with woodcuts as required.

It will comprise:

(1) The Transactions of the Society, being the papers read (or taken as read) at the Ordinary Meetings, and the President's Address at the Annual Meeting.

(2) The Proceedings of the Society, being a report of the business transacted at the Ordinary and Annual Meetings, including any discussions on the subjects brought before the Meetings.

(3) Notes and Memoranda, being extracts from the articles in English and Foreign Journals, Transactions, &c., which relate to the Microscope or the subjects of Microscopical Research, together with notes of any other current matters of interest to Microscopists.

(4) Bibliography, being a list of the new Books and of the contents of English and Foreign serials, &c. (so far as they relate to the Microscope or the subjects of Microscopical Research), most of which are to be seen in the Society's Library.

Special importance is attached to the "Notes and Memoranda," which are intended to present a summary of what is doing throughout the world in all branches of Microscopical Research. Whilst extracts from English publications will not be excluded, preference will be given to those of foreign countries, as being less easily accessible. Amongst these will be included the Transactions and Proceedings of the Academies of the United States, France, Belgium, Germany, Austria, Italy, and Russia, together with the Microscopical, Botanical, and Zoological journals of those countries.

The pages devoted to "Bibliography" will also, it is hoped, prove useful, as giving in a condensed form information that cannot be so readily obtained otherwise.

Lastly, it will not be out of place to remind the Fellows that the editing of the Journal has rested with those who, being much occupied in other pursuits, have not been able to give it undivided attention.

THE

ROYAL MICROSCOPICAL SOCIETY.

The Society was founded in 1839 (incorporated by Royal Charter in 1866) for the communication and discussion of observations and discoveries tending to improvements in the construction and in the mode of application of the Microscope, or relating to subjects of Microscopical observation.

The Society consists of Fellows, Honorary Fellows, Corresponding Fellows, and Associates.

The Council is elected annually by the Fellows, and is composed of the President, four Vice-Presidents, Treasurer, two Secretaries, and twelve other Fellows.

Candidates for admission as Fellows must be proposed by three or more Fellows, who must sign a Certificate of Recommendation stating the names, residence, description, and qualifications of the Candidate, of whom the proposer whose name stands first upon the Certificate must have personal knowledge. This Certificate is read at the next Ordinary (or Annual) Meeting, and the Candidate is balloted for at the succeeding Meeting.

The Entrance Fee is 2*l.* 2*s.*, and the Annual Subscription (payable in advance on election, and subsequently on 1st January annually) is 2*l.* 2*s.* Future payments of the latter may be compounded for at any time by a payment of 21*l.* Fellows elected in the months of October, November, or December will not be called upon for a second subscription during the succeeding year, and Fellows absent from the United Kingdom for a year, or permanently residing abroad, are exempted from one-half the usual subscription during absence.

The Ordinary Meetings of the Society commence on the second Wednesday in October, and are continued on the second Wednesday in each month until June. They are held at King's College, Strand, W.C., and commence at 8 P.M. Visitors are admitted by the introduction of Fellows.

Twice in each Session an evening is devoted to the exhibition of objects and apparatus of novelty or interest relating to the Microscope or the subjects of Microscopical Research.

The Journal of the Society, containing its Transactions and Proceedings, with other Microscopical information, is published bi-monthly, and is forwarded free of charge to all Fellows.

The Library of the Society at King's College is open for the use of Fellows on Mondays, Tuesdays, Thursdays, and Fridays, from 11 A.M. to 4 P.M., and on Wednesdays from 7 to 10 P.M. It is closed during August.

Forms of proposal for Fellowship, and any further information, may be obtained by application to the Secretaries, or to Mr. Walter W. Reeves, Assistant-Secretary, King's College, Strand, W.C.

THE

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ERRATA.

Page 141, line 14, *for* "in Fig. 2", *read* "above".

Plate VII., column 6, line 13 of the Computation: the signs for degrees, &c., are erroneously given as figures (0, 1, 11).

Plate XIII. The numbering of Figs. 3 and 4 should be transposed.

JOURNAL

OF THE

ROYAL MICROSCOPICAL SOCIETY.

MARCH, 1878.

I.—THE PRESIDENT'S ADDRESS.

H. C. Sorby, F.R.S., P.G.S.

Plate I.

When first I commenced to write an address for this evening, I intended to call your attention chiefly to some special subjects which have been prominently brought before our Society during the last year or two. I never contemplated entering into certain questions with which I am so little acquainted practically that it would be presumptuous to express any confident opinion of my own. I thought it would be far better to enter at greater length into the consideration of such special subjects as I have studied sufficiently as to be able to treat them in a more or less original manner. I proposed to lay before you an account of some further observations of my own in connection with the visibility of very minute objects, and to discuss what has been done and said by others in relation to this subject; and also to consider some points in the construction of object-glasses, which have more particularly attracted my attention during the last few years. However, when I came to write out only a superficial account of another subject, I soon found that it alone was even more than enough to occupy your attention this evening. Being an almost entirely new application of the microscope, I thought it sufficiently suitable for the present occasion, and that it would be better to treat of it in some detail, rather than say so little as to make it scarcely intelligible, in order to find room for several other subjects. I propose, therefore, now to describe some simple additions to the microscope, which

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DESCRIPTION OF PLATE I.

Figs. 1 to 6 represent the images of a small circular hole, viewed with a microscope through various crystals.

Figs. 7 and 8 are diagrams of mounted objects.

Figs. 9, 10, and 11 show the appearances seen on viewing the cross lines of the grating through different crystals.

enable us to study certain classes of objects in a far more satisfactory manner than heretofore. The very striking facts on which this method is based were first shown publicly at our scientific evening meeting on the 18th of April last year, when their true explanation was still unknown; and were again shown at a subsequent meeting on the 31st of October, after the general principles of the subject had been sufficiently well established. The various facts seemed to attract so much attention, that I have often felt desirous to bring the subject before this Society, and now take the opportunity, since I fear another may not occur for some time to come.

In the first instance my attention was exclusively directed to the application of the method to the study of comparatively large portions of minerals, having a thickness of $\frac{1}{4}$ of an inch or more, in order that the various measurements might be made with sufficient accuracy to establish general principles, and to verify or correct certain theoretical deductions of Professor Stokes, who undertook that part of the subject. The results fully convinced me that the method would enable us to determine, with very considerable accuracy, some of the most important optical constants of crystalline minerals, provided that the section be cut in the plane of any two of the axes. This alone was a great gain for mineralogy, since, in order to determine them by the methods previously adopted, more numerous and complex measurements were necessary, and it was requisite to cut the section in one very special direction. The new method enables us to approximately determine several important particulars, no matter what may be the direction in which the section is cut. This is of course a very great advantage when we come to apply it to the study of thin sections of rocks, in which the minerals lie in every possible position. Even when comparatively large specimens and a low magnifying power are used, the special characters observed by this method depend entirely upon the collection by an object-glass of more or less divergent rays. It is not, as so often happens, a case where the microscope merely magnifies an appearance which might be seen with the naked eye or a simple lens, but a new class of properties is, so to speak, created by the peculiar optical conditions of a compound microscope. Though the deductions have a direct bearing mainly on mineralogy and theoretical optics, it would not therefore be out of place to enlarge even on this department of my subject, but still I will not say more than is absolutely necessary, since I am anxious to describe more fully the applications of the new method to the study of minute objects somewhat highly magnified.

Before proceeding any farther it will, I think, be well to give a short history of this subject.

At the meeting of the Royal Microscopical Society, November, 1876, Dr. Royston-Pigott exhibited and described an instrument which he named a *refractometer.* His paper was subsequently published, with a plate, in the 'Monthly Microscopical Journal.'* The principle made use of in applying this instrument was the increase in the focal length of the object-glass of a microscope, caused by looking through media of different refracting power. The author showed that if t be the thickness of this medium, and d the amount of the displacement of the focus, the index of refraction μ may easily be calculated from the following equation:

$$\mu = \frac{t}{t - d}.$$

In the instrument described by Dr. Royston-Pigott, the amount of this displacement, and also the thickness of the object under examination, were determined by means of a micrometer screw fixed under the stage of the instrument, in such a manner that it became unsuitable for use as an ordinary microscope.

At the time of the reading of this paper I was much struck with the general method employed, and in the subsequent discussion I said that probably some modification of it might prove very useful in studying minerals. I have now succeeded in proving this very completely.

From the first I was anxious to contrive some arrangement that would enable us to obtain the necessary data with an ordinary microscope, or at all events with one so slightly modified as not in any way to interfere with its general use; and I think that I have succeeded in accomplishing this by a very simple addition, which will also enable us to use the instrument for a number of purposes not originally contemplated.

Practically, the application of the method I propose is very simple. If an object be placed on the stage of a microscope and the focus adjusted, on placing over it a plate of some highly refracting substance the focal length is increased, and hence, to bring the original object into focus, the body of the microscope must be moved farther from it. In order to measure the amount of this displacement, nothing, therefore, is required but some means for accurately measuring the distance over which the body of the microscope is thus moved. This may be roughly done with a small scale, accurately divided to $\frac{1}{100}$ths of an inch; but it is far better to have an attached scale and vernier, so as to be able to read to $\frac{1}{1000}$ of an inch, and to estimate half that quantity. The thickness of the specimen is easily measured by focussing first the particles of dust on the surface of the glass plate supporting the mineral, and then those on its upper surface. Several observations should be made of the position of these different planes, as shown by the readings on the scale, and the means taken, in order to

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* Vol. xvi., 1876, p. 294.

compensate for small accidental errors, and care must of course be taken to avoid any that might be caused by imperfections in the instrument. If the section of the mineral be covered with thin glass, which in most cases is very desirable, its apparent thickness must be measured, and due allowance made for it in calculating out the results. It is also requisite to deduct from the indices given by the formula $\mu = \frac{t}{t - d}$ a small quantity due to the effects of spherical aberration which varies with the aperture and correction of the object-glass, and also with the value of the index in each particular case. In order to obtain as accurate measurement as possible, a number of precautions must be taken, which are all simple enough, but it would occupy too much time to describe them in detail. With proper care the errors in the values of t and d ought to be certainly less than $\frac{1}{1000}$ of an inch. The accuracy with which the indices of refraction can thus be determined depends much on the thickness of each specimen, but if it be from $\frac{1}{8}$ to $\frac{1}{4}$ of an inch, the errors ought to be limited to the third place of decimals. In practically employing this method it is of great importance to have some object which gives a very definite focus. In the first instance I made use of a glass plate having very fine parallel scratches, made with the finest emery paper; but I soon found that it would be very convenient to have more definite and equidistant parallel lines, not in any way affected by moving the stage. This can be accomplished by having them ruled $\frac{1}{100}$ of an inch apart on a glass plate, fixed as far as possible below the lenses of an achromatic condenser, with a small central stop, which gives at the focus a much reduced image easily adjusted either a little below the lower or upper surface, or nearer the centre of the specimen, according as its shape may make it necessary, so that the light may pass to the object-glass as equally as possible from all sides. It is also extremely useful to have an iris diaphragm fixed just below the grating, so as to be able to obtain an image of a circular hole of any requisite diameter. I had two sets of lines ruled on the same surface at right angles to each other, in order that there might be less chance of mistaking any striæ in the mineral for a single system of lines, and that either system might be used if the other were obscured. This arrangement has fortunately led to the discovery of an entirely new class of optical properties.

Unifocal and Bifocal Images.

On looking at the double system of lines without any intervening object, both sets of parallel lines are seen at the same focus. If a plate, with parallel flat surfaces of glass or of any transparent mineral which has no double refraction, be placed on the stage of the microscope, with its surfaces perpendicular to the line of vision, the two systems of lines can still be seen at the same focus, no matter what may be the azimuth of the lines to the axes of the crystal. The image may thus be said to be *unifocal*, and to have no special *focal axis.* The index of refraction, determined as above explained, is that of an ordinary ray. On the contrary, if the mineral possesses double refraction, the phenomena seen by means of the extraordinary ray may be totally different, and as though a cylindrical lens had been placed in front of the object-glass. In order to be able to examine separately the two rays polarized in opposite planes, a Nicol's prism must be used over the eye-piece, arranged at such an azimuth as to transmit one or other ray alone. The ordinary ray has just the same properties, and is strictly unifocal, no matter what may be the direction of the section of the crystal; but the characters of the extraordinary ray differ greatly, according as the section is cut perpendicular, oblique, or parallel to the principal axis. I cannot refer to a better example than calcite. On examining the image of the circular hole and of the grating through a section parallel to the axis, the plane of polarization of the Nicol being arranged perpendicular to the axis of the crystal, so that only the extraordinary ray is transmitted, it will be found that at two different foci the circular hole is elongated in opposite planes, and that both sets of lines are invisible, unless they are nearly parallel and perpendicular to the axis, and that there are two focal points, separated from one another by an interval somewhat more than one-eighth of the thickness of the section, at each of which only one system can be seen at once. The image is thus truly *bifocal*, and has a definite focal axis, and the lines are distinctly visible only when parallel or perpendicular to this axis. When determined in the manner already explained, the index of refraction for the lines parallel to the principal axis of the crystal is the true index of the extraordinary ray, whereas that for the lines perpendicular to this axis is only an *apparent* index, and is equal to the square of the index of the ordinary ray, divided by that of the extraordinary.

The striking difference between a unifocal and a bifocal image becomes at once intelligible if, instead of a grating, we examine through the mineral the image of a small circular hole, as Fig. 1. In the unifocal image this is seen undistorted, well defined all round at one definite focus; whereas in the bifocal image there is no focal point whatever at which the hole can be seen of its true size and shape. There is one focal point for the two opposite sides of its circumference which are parallel to the focal axis, and at this focus the circle is drawn out parallel to that axis into a long band, and there is another focal point for those parts of the circumference which are perpendicular to the axis, and the image is then drawn out in a direction perpendicular to that of the former image, as shown by Figs. 2*a* and 2*b*. At an intermediate focal adjustment we see merely a large circle without any definition. It therefore follows that the series of black points forming a line would be similarly drawn out at the two foci into lines, and if these overlapped, as they would if the line were at that particular azimuth, we should appear to have a well-defined black line, whereas at other azimuths this line would be spread out into a band, and so diluted with white light, as to be practically invisible. In a section parallel to the axis the images of the small hole are directly superimposed, but if we examine it through a section parallel to the cleavage they are widely separated in the plane of the principal axis, as shown by Fig. 4, and appear to lie at different levels. That due to the ordinary ray remains in the centre of the field, and is not in any way distorted, whereas that due to the extraordinary ray is thrown out of the centre from the line of axis, and is both distorted and fringed with colour. This image is very decidedly bifocal, but one system of lines is much obscured by coloured fringes, unless we illuminate with the approximately monochromatic light transmitted by red glass. When the section is cut in planes more and more inclined to the axis, the bifocal image becomes more and more nearly unifocal, and when the section is perpendicular to the axis it is unifocal, but can be distinguished from that due to the ordinary ray by causing the light to pass obliquely. We then see two images with both sets of lines, at perfect focus, directly superimposed at two very widely separated levels, as though there were two sets of lines ruled on opposite sides of a glass plate. One gives the true index of refraction of the ordinary ray, and the other an apparent index, which is equal to the square of the true index of the extraordinary ray, divided by the true index of the ordinary. On examining the small circular hole it is seen undistorted, in perfect focus, at two widely separated foci, surrounded with a large nebulous circle, due to the other image seen out of focus, as shown by Fig. 3.

All these phenomena are totally unlike what can be seen with the naked eye in looking directly through sections cut either parallel or perpendicular to the axis. A white or black spot placed close to the specimen is then not even divided into two. The phenomena seen with the microscope depend entirely on the power of the object-glass to collect divergent rays. In the case of substances having no double refraction, this divergence merely obeys the laws of ordinary refraction, and enables us to measure the index in the manner already explained; but, in the case of the extraordinary ray, the light is bent from the normal line unequally and in opposite directions, and may thus enter the object-glass at an angle of divergence greater or less than that depending on the index of refraction, according to the direction of the section, and to whether the double refraction is negative or positive. Thus, for example, in the case of calcite cut perpendicular to the axis, the light diverges equally all around the axis, less than normally, and therefore the focal point of objects seen through the section is made abnormally short, and the apparent index abnormally small, being, in fact, only 1·332, whereas the true index of the extraordinary ray is 1·480, and of the ordinary 1·658.

Crystals like orpiment or aragonite, which have two optic axes and three different indices, have no ordinary ray, and no permanently unifocal image, but two bifocal images polarized in opposite planes. We may thus have four different apparent indices. In the case of orpiment the image of a small circular hole is drawn out at two different foci into two crosses, as shown by Fig. 5. Each cross is produced by the combination of two bands of light polarized in opposite planes, each due to an extraordinary ray, analogous to the single extraordinary ray of calcite. In the case of aragonite, cut perpendicular to the principal axis, the arms of the crosses are nearly equal, but spread out in the manner shown by Fig. 6. This spreading out varies according as the aperture of the object-glass is large or very small. If the section is in a plane somewhat oblique to the principal axis, one bar of the cross is distorted into an irregular circle, and one arm of the other bar is spread out into a sort of crescent.

A remarkable peculiarity of crystals which thus give two well-pronounced bifocal images, is that though they may be perfectly transparent, and distant objects distinctly visible through them with the naked eye, the systems of lines at right angles to each other are perfectly invisible with the microscope, except at particular azimuths. I was extremely surprised at this fact when first I observed it, and could not understand the reason of this apparently strange peculiarity.

When the section is cut parallel to the principal and to one of the secondary axes, we obtain a cross with unequal arms at four different foci; and when cut parallel to the principal, and along the diagonal of the secondary axes, one image has the bifocal character very strongly developed, and the other is almost or quite unifocal, but can be shown to be also due to an extraordinary ray, by causing the light to pass obliquely.

If we wish to ascertain the real value of the indices, we must bear in mind the following facts: The image due to the light passing through substances not possessing double refraction, or to the ordinary ray of crystals belonging to the rhombohedral and dimetric systems, has no special focal axes, and the apparent index is the true index, no matter what may be the direction of the section. Doubly refracting crystals give two images, one or both bifocal, and have one or three principal focal axes, according as they have one or two optic axes. These *focal axes,* which correspond to Fresnel's so-called *axes of elasticity,* are invariably perpendicular to the plane of polarization of the images, and their direction may thus be determined with accuracy, if the section can be examined sideways with polarized light. In the case of any bifocal image, one of the apparent indices is true only when the corresponding principal focal axis is parallel to the plane of the section. If, therefore, a natural or artificial plate of a crystal be parallel to two principal axes, each image gives one true index, and the third can be calculated. If, however, parallel to only one axis, only one index can be determined, whilst if not parallel to any axis, none of the true indices can be directly measured.

When the section is parallel to two of the focal axes, the three true indices being μ, μ', μ'', the four observed indices are

From lines perpendicular to the plane of polarization	μ	μ'
From lines parallel to the plane of polarization	$\frac{\mu''^2}{\mu}$	$\frac{\mu''^2}{\mu'}$

Representing these observed quantities by a, b, c, and d, we have $\mu'' = \sqrt{a\,c}$ or $\sqrt{b\,d}$ and $\frac{a}{b} = \frac{d}{c}$; but since the measured values may be affected by errors of observation and also by those depending on the section not being cut accurately, these relations may not be found to be strictly true, and there may be a considerable difference between the two calculated values of μ''. In this case their mean may be adopted as the most probable approximation; but it could not be correct if the section does not lie more or less closely in the plane of two of the three focal axes. This may, however, be at once known by observing whether the two images are superimposed or separated; provided that the two polished surfaces are truly parallel to one another. If with or without alteration in focal adjustment the two images are seen to be directly superimposed, the section must be almost or quite in the plane of two axes, whereas if there be a lateral displacement the section must be inclined to that plane.

Some anomalous results are seen in minerals which have such a strong dichroism that one image is completely invisible, or which are so made up of alternating plates of different refractive powers that the lines parallel to them are obscured by reflexion; and various other special peculiarities might be named if time would permit. On the whole we may draw the following conclusions: crystals having no double refraction give only one image, which is strictly unifocal; crystals having only one optic axis give two images, one truly unifocal and the other bifocal, unless the section is nearly perpendicular to the optic axis; and crystals having two optic axes give two images, both of which are bifocal, unless the section is nearly parallel to four different planes much inclined to the plane of the optic axes. The separation of the focal points in bifocal images varies directly as the intensity of the double refraction and the thickness of the specimen; and if the double refraction be weak and the section too thin, the bifocal character of the image may not be recognizable with an object-glass of too low power. Sometimes, however, as in orpiment, the difference in the focal distances amounts to more than one-fifth its thickness. As a general rule, all the more important facts may be observed qualitatively, no matter what may be the direction of the section, though it may not be suitable for determining the true value of the indices. The natural planes of crystals belonging to all those systems in which the axes are rectangular, are, however, often in the proper direction; and, unless their surfaces be very irregular, perfectly satisfactory results may be obtained by mounting the specimens on glass and fixing over them a thin glass cover with Canada balsam, or by using oil of cassia or some other liquid of nearly the same refractive power as the specimen under examination, if it be desirable not to use balsam.

Applying this method to the study of various minerals, the difference between them is found to be very great. We can, usually, at once see whether they give a single unifocal image or one or two bifocal images, and form a very good opinion respecting the intensity of the double refraction, and easily determine whether it is positive or negative. There can never be any question as to the index of the ordinary ray since the observed index is always true, and in many cases the index or indices of the extraordinary ray can also be determined. All these facts combined furnish data so characteristic of the individual minerals, that it would usually be difficult to find two approximately similar. In any case we have data which may often be of the greatest assistance in identifying the different species. Of course this method cannot be employed if the specimens are opaque, or have such a fibrous or laminar structure as to prevent our distinctly seeing the lines of the grating; but the presence of a vast number of fluid cavities and minute crystals or granules may not signify much.

The above sketch of some of the leading principles involved in this method of research would be very inadequate if on the present occasion it were desirable to fully explain its application to the study of crystals sufficiently large to be cut in a proper direction, and to make it possible to determine the indices with considerable accuracy. It will, however, I hope, be enough to indicate what we might expect to be able to learn by applying the method to the study of thin sections of rocks. For some time I feared that it never would be possible to obtain satisfactory results with sections sufficiently thin to be useful for ordinary microscopical examination, since it appeared probable that the errors of observation would be as great as the differences between the indices of the various minerals usually met with in rocks. In order to identify these with confidence, there ought to be no considerable error in the second place of decimals of their measured indices. I, however, now find that it is possible to make sufficiently accurate measurements with sections less than $\frac{1}{100}$ of an inch in thickness, which had been prepared many years ago, and ground down as thin as was thought desirable for ordinary microscopical examination. Though my apparatus is still far from perfect, I have been able to obtain satisfactory results with sections only $\frac{1}{500}$ of an inch in thickness, and even less.

Application of the above Method to the study of thin Sections of Rocks.

When first I commenced to apply this method with thin sections, I very naturally dealt with them in the same manner as I had previously adopted in the case of thicker specimens, and determined the values of t and d by means of the scale attached to the body of the microscope. The next step was to determine their values by means of the rotation of the roughly graduated circular head of a well-constructed, fine adjustment screw. I found that with a $\frac{4}{10}$ object-glass of small aperture a difference in adjustment corresponding to $\frac{1}{100}$ of a revolution was just certainly apparent, which corresponds to about $\frac{1}{16000}$ of an inch. Consecutive measurements may vary by several such divisions, but by taking the mean of a number of observations it appears to me possible to measure to at all events $\frac{1}{10000}$ of an inch, and probably less. Since the true value of each revolution gradually diminishes from the top downwards, the mean value of d must be determined from observations made both at the upper and lower limits of the range of the adjustment required to determine the value of t. If, however, the range be small, no such precaution need be taken. Of course when thus employing a microscope for such extremely accurate quantitative observations it is absolutely necessary that all the movements should be thoroughly well made, and that no other part but the fine adjustment should by any accident move to such an extent as even $\frac{1}{10000}$ of an inch. A general construction, which would do well enough for mere magnifying purposes, might thus be totally unfit for such refined quantitative observations.

The above results were obtained with my ordinary condenser and object-glasses. I find that they can be greatly improved by using a condenser of shorter focal length, specially constructed so that it can be adjusted for different thickness of glass. The object-glasses should also possess special characters. It is more important that the spherical aberration should be well corrected, than that the aperture should be large, or the image achromatic, since red light is generally used for illumination.

When the thickness of a section is considerable it may be allowable to assume that the polished surfaces are in contact with the thick glass plate on which it is mounted, and with the thin glass cover; and we may disregard the thickness of the intervening Canada balsam; but when we come to deal with very thin sections this would lead to very great errors. It is also necessary to bear in mind that both the thick and the thin plate glass are not of uniform thickness, so that measurements made in any one part would apply only to closely adjacent parts. It is also very necessary to remember that the thickness of any transparent substance measured in the manner described, by looking *through itself* is not the same as its real thickness, but is approximately equal to its real thickness divided by its index of refraction. In accordance with these principles the most legitimate process appeared to be to measure the total thickness of the mineral, of the upper and lower balsam, and of the covering glass, and to deduct from it the true thicknesses of the balsam and of the glass, calculated from their apparent thickness; and also to determine the displacement of the focus due to the mineral alone, by similar means. Such a process is, however, very tedious, and the chances of error are greatly increased by the large number of measurements required, and I have therefore been led by degrees to greatly simplify and improve it. My experience so far leads me to recommend three different methods, one or other of which appears to be the best, according to circumstances. If the specimen be somewhat thick, and the indices of the minerals to be observed not so different from that of Canada balsam as to make a slight error in its thickness of importance, the balsam between the glass slide and the covering glass should be carefully cleaned out along one edge of the section. Fig. 7 shows what would then be the general relation of the different parts as seen in section. The thickness and effect of the covering glass (g) may then be entirely neglected, since the true distance between it and the glass slide is easily measured, and so is the total displacement of the focus due to the mineral (m) and the upper and lower balsam (b, b'). Unless the balsam be relatively very thin its apparent thickness must be measured and due allowance made for it in calculating the results. The mineral observed ought to be as near to the edge as possible, to avoid any errors due to varying thickness.

As an illustration of the use of this method, I give the particulars in the case of a section of the pitchstone of Arran which is about $\frac{1}{80}$ of an inch in thickness. The space between the glasses was 2·54; the apparent thickness of the upper balsam ·12, and of the lower ·22. The total displacement of the focus was ·89, from which must be deducted ·19 for the balsam. Hence the mean apparent index is $\frac{2 \cdot 03}{2 \cdot 03 - 70} = 1 \cdot 526$. This corrected for the effects of the aperture of the object-glass would be about 1·52. One image was very decidedly bifocal, and the other very nearly unifocal, as though the crystal had two optic axes, but two of the three indices nearly equal. In all these characters this mineral corresponds most closely with adularia, so that its general composition cannot differ much from that variety of felspar. The only question is whether the double refraction be not positive, instead of negative, which it does really seem to be.

The only serious objection to this direct method of comparison is the chance of error in measuring the thickness of the balsam used in mounting, and when this is relatively great, it is better to adopt one or other of the following systems, in which the *thickness* of the balsam may be entirely neglected.

It can easily be shown that if parallel plates of two transparent substances be of exactly the same thickness, their apparent thickness (t and t') *as measured through themselves*, varies inversely as their indices of refraction (μ and μ'). If then the index of one of them (μ) be known, that of the other can easily be calculated, thus

$$\mu' = \mu \frac{t}{t'}.$$

These relations enable us to ascertain the approximate value of the indices of refraction of minerals in very thin sections without any special preparation, by making only a few simple measurements.

Fig. 8 shows the section of the edge of a thin plate of rock covered with a thin glass which projects beyond it, the space between the two glasses being filled with hard Canada balsam (b), as shaded. Now in this case, if we measure the apparent thickness of any mineral near the edge, by focussing first to its upper and then to its lower surface, and also observe the difference in the focal position of the lines of the grating, as seen through the mineral and through the balsam alone, we can at once calculate the index of refraction. A moment's reflection will show that the thickness of the balsam over and above the thin slice need not be taken into account, since the displacement in the focal length only corresponds to a thickness of balsam equal to that of the mineral, whatever it may be. The only source of material error which need be taken into consideration is a possible variation in the index of the balsam. I assume that it is the hard and brittle balsam used to fasten down the specimen before it is ground thin, and not the soft balsam used to fix on the covering glass. I find that the index of such hard balsam varies but little, and is about 1·54.

As an illustration of what may thus be done, I will describe the results in the case of several different minerals in a section of a dolerite from near Glasgow, which is only about $\frac{1}{400}$ of an inch in thickness. I give the measurements in turns of the head of the fine adjustment.

A colourless mineral containing fluid cavities, filling up cavities between the original minerals, was ·207 turn in thickness, *as measured in itself*, and when compared with the hard Canada balsam the *decrease* in focal length in the latter was found to be ·007, whence we have $\mu' = 1{\cdot}54 \times \frac{{\cdot}207 - {\cdot}007}{{\cdot}207} = 1{\cdot}49$. In accordance with the principles described in my address at the Mineralogical Society,* this clearly shows that this mineral is a zeolite, probably analcime. In a similar manner in the case of a mineral which looks very much like some variety of felspar, the focal length in the balsam was increased, and the index was found to be $1{\cdot}54 \times \frac{{\cdot}214 + {\cdot}025}{{\cdot}214} = 1{\cdot}61$, which clearly shows that it cannot be any felspar which contains a large amount of alkali, since that would reduce the index very considerably. Theory led me to conclude that the index of labradorite should correspond closely with this. I am not aware that its indices have been previously determined. I found that they are about 1·621, 1·617, and 1·597. The mean of these is about 1·612, which agrees so closely with that of the mineral in the section, that it must almost certainly be labradorite, or some felspar of similar chemical composition.

In like manner I found that the mean index and the focal character of the images given by another colourless mineral closely correspond with those characteristic of calcite. I also found that the mean index of a dark-coloured mineral was 1·79 or 1·80. No common silicate which does not contain much iron has so high an index. Both in this and in other optical characters it corresponds closely with the black augite in the lava of Vesuvius, which has a mean index of 1·785.

The only important objection to this comparison with balsam is that its index may vary. It is, however, always possible to determine what its real index is. Thus, for example, on comparing a

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* 'Mineralogical Magazine,' vol. i. p. 193.

transparent mineral filling a cavity in an old lava of Vesuvius with fresh soft balsam, having an index of about 1·44, I found that the index of the mineral was about 1·49, which closely corresponds with that of analcime, or some other analogous zeolite.

Very frequently in large sections of rocks some interesting object may occur so far from the edge that direct comparison with the balsam might lead to serious error. This difficulty may be overcome by comparing it directly with some other mineral the index of which is either known or has been previously determined. For this purpose quartz is eminently suitable, since its mean apparent index, which is about 1·55, does not vary materially; it is so frequently met with, and so easily identified. By thus comparing with quartz a reddish mineral having no double refraction, met with in a porphyritic rock from Naddle Fell, I found that its index was about 1·82, which clearly indicates that it is a garnet containing much iron.

To be able thus to determine the index from such thin sections, and from portions of minerals with no solid transparent part more than $\frac{1}{200}$ of an inch in diameter, will for the future make it possible to identify the mineral constituents of rocks in a far more satisfactory manner than heretofore. In order to obtain such good results as those described from very thin sections, it is, however, necessary to take the means of many observations, and thus eliminate the unavoidable errors of individual observations.

I have so far considered almost exclusively the mean indices of refraction and not the separate indices of uniaxial and biaxial crystals. I do not propose to enter at large into this part of my subject, but still I think it is not desirable to omit it altogether.

The meteoric irons of Krasnojarsk and Rittersgrün contain a clear transparent mineral which has been proved to be olivine by the usual methods. I subjoin the values of the three indices, and give for comparison those of olivine, according to Des Cloiseaux:

Krasnojarsk	1·71	1·69	1·68
Rittersgrün	1·70	1·68	1·66
Olivine	1·70	1·68	1·66

Such a close agreement clearly shows that the methods I have adopted are correct, and give very satisfactory results when the section is not too thin, and a sufficient number of observations made to eliminate accidental errors.

In the case of the black augite of the lava of Vesuvius I found that the three indices were about 1·80, 1·76, and 1·75. This proves that there are two optic axes, and that the double refraction is positive, in which it corresponds with diopside; but the refractive power is very considerably greater in this black variety of augite found in lava, no doubt owing to the presence of a larger amount of iron.

It will thus be seen that the study of the indices of refraction in the manner I have described enables us not only to identify with more confidence each particular mineral, by bringing to bear a most important class of optical characters, hitherto unavailable in studying thin sections of rocks, but also in some cases enables us to form a very satisfactory opinion respecting certain variations in chemical composition. Though all this is possible, yet it most certainly requires a far more strict attention to minute details than is ever taken into account in ordinary microscopical research. The accurate measurement of the up and down movement of an object-glass to within $\frac{1}{10000}$ of an inch is a very different matter to measuring any such visible quantity with an ordinary micrometer, but then we must remember that by this step we convert the microscope into an all but new physical instrument. However, if some microscopists might not feel disposed to attend to all the minute detail necessary for accurate quantitative observations, the methods now described may easily be employed qualitatively, and many valuable conclusions drawn from what may be seen without any actual measurements. The difference in focal distance and the focal character of the images are easily observed, and much may also be learned from the manner in which the images are separated. This alone may prove that a minute crystal, seen under the microscope, has two optic axes inclined to one another at a greater or less angle. Since this is a fact of some interest, and has I believe not yet been applied to microscopical research, it will be well to notice it in some detail.

As previously named, if a parallel plate of any doubly refracting mineral be cut in the plane of any two of the focal axes, the two images, polarized in opposite planes, are not separated horizontally. When cut obliquely, the results vary with the direction of the section and the character of the crystal. If it have one optic axis, and therefore only one focal axis, the line along which the images are separated is in all cases parallel to this axis, and therefore parallel to the plane of polarization of one of the images. If it have two optic axes, and therefore three focal axes, and the section be cut obliquely to two of them, the images will be separated in relation to both of them, and the resultant line of maximum separation will not be parallel to the plane of polarization of either image. These facts will be better understood by means of Figs. 9, 10, and 11.

In both cases the planes of polarization of the two images are supposed to be parallel to one or other of the two systems of perpendicular lines of the grating (Fig. 9). This is easily arranged practically. The plane of polarization of a polarizer under the stage is arranged parallel to one set of lines, and the analyzer over the eye-piece crossed so as to give rise to a naturally dark field. The object is then introduced and rotated until it is in such a position that it does not in any way depolarize the light. The polarizer and analyzer are then removed, and the microscope so adjusted that the lines of the grating are seen in good focus through the crystal. If both systems of lines are doubled, as in the case of the olivine of the Rittersgrün meteorite, shown by Fig. 11, the crystal must have two optic axes, inclined to one another at a considerable angle. If, however, only one system is doubled, as in Fig. 10, it may be a two-axed crystal, cut obliquely only to one focal axis; but if on examining a number of different crystals, scattered in various positions through the thin section of rock, only one system of lines is invariably doubled, the mineral must either have only one optic axis or two which are inclined to one another at a small angle, two of the three indices of refraction being very nearly equal.

A little care is sometimes necessary in order to see the lines well separated. Frequently they lie in different planes, so that they cannot be seen in focus at the same time, especially if too high a magnifying power is used. On the contrary, the horizontal separation may be so small that they cannot be seen separately, unless a high power is employed. The extent of this separation varies directly as the intensity of double refraction, and as the thickness of the section, but also, as previously named, depends on the direction in which it is cut. With a $\frac{1}{5}$ object-glass and a powerful eye-piece, there is no difficulty in seeing that one set of lines is divided by calcite, even when it is only $\frac{1}{4000}$ of an inch thick, since its double refraction is so strong, but a much greater thickness of some minerals would be necessary. Care must be taken not to confound this true separation with any duplication of the lines due to accidental reflexions, which are distinguished by varying with slight movements of the object.

If any individual crystal be so cut that its optical characters cannot be determined by means of this visible horizontal separation of the lines, it must necessarily be cut in such a direction as to enable us to determine them by means of the focal character of the images, the one method being the most applicable just when the other breaks down.

As a practical example, I will describe what I observed in a section of lava from Vesuvius about $\frac{1}{300}$ of an inch thick. It contains a few scattered crystals of what I believed to be olivine. In some cases neither system of lines was sensibly divided, but both images were bifocal, and I obtained for the three indices about 1·77, 1·72, and 1·64. In some examples only one system of lines was divided, but in others both, one being separated by about $\frac{1}{12000}$ of an inch, and the other by about $\frac{1}{24000}$, the former being readily resolved by a $\frac{2}{5}$ object-glass, but the other requiring a $\frac{1}{5}$. It will thus be seen that both classes of facts clearly prove that the mineral has two optic axes, and that the three indices of refraction differ very considerably, but have a mean value of about 1·71. This is ·03 higher than that of the variety met with in the meteorites previously mentioned, probably owing to a variation in the amount of iron, though at the same time it is only fair to say that in measuring only once the indices in a section $\frac{1}{300}$ of an inch in thickness, we cannot be sure that the second place of decimals is perfectly correct. On the whole, there can be very little doubt that it is olivine, since, so far as I am aware, no other common mineral has corresponding optical characters.

In this section of lava are also scattered crystals of augite, their mean index of refraction being 1·80. By using a $\frac{1}{5}$, I could just separate one system of lines, but the section is too thin to enable me to separate the other system. In the case of another section, which is nearly three times as thick, I found that the indices were about 1·80, 1·76, and 1·75, and I could just see that the second system was also double, but the lines much less separated than the others, which agrees with what would result from two of the indices being nearly equal. We thus prove most completely that the mineral has two optic axes inclined at a small angle, and has positive double refraction. In all these characters it differs so much from the olivine, that they could not possibly be confounded together, even if they were not otherwise well distinguished. I am not yet quite certain whether the above-described characters enable us to distinguish augite from hornblende. As far as my present observations go, the mean indices of refraction of the dark varieties of hornblende and of augite are nearly the same, but all my sections of hornblende show the lines very decidedly less separated horizontally than in the case of augite of equal thickness, as though the double refractions were less intense.

The principal difficulty in at once applying this method of study is that our knowledge of the indices of refraction of even some of the commonest minerals is so imperfect. Des Cloiseaux, in the 'Annuaire du Bureau des Longitudes' for 1877, gives what appears to be a very complete summary of what was then known. The minerals in this list are all but exclusively those which can be obtained in comparatively large and transparent crystals, since the indices could not be determined by the old method if they were small and somewhat opaque. In many cases also only the mean index of biaxial crystals is known, and not their three different indices. What we ought to know is the value of all the indices of the commoner and more opaque varieties of the constituent minerals of rocks. By the methods I have described these indices could soon be determined with sufficient accuracy for the use of practical petrologists, and they would then be able to study the microscopical structure of rocks in a more satisfactory manner than heretofore, and at once clear up a number of interesting questions, which, however, relate more to geological and mineralogical problems than to the construction and use of the microscope. I will not, therefore, further occupy your time in describing them, since I feel that I may have already made my address somewhat too special in my anxiety to point out a new direction in which the practical application of the microscope may be further developed.

I must, however, not conclude without describing some applications of my method of study in the case of organic structures. There can be no doubt that it will enable us to decide several interesting questions connected with the constitution of shells. If sections were prepared specially for this purpose the measurements might be made with abundant accuracy. However, in order to test what may be done, I have merely used sections cut many years ago to show the organic structure. Though they are only about $\frac{1}{1000}$ of an inch thick they enabled me to learn many interesting facts. Thus, for example, in the case of a shell of *Pinna*, cut nearly parallel to the prisms, it was easy to see that when they are cut somewhat obliquely only one system of the lines of the grating is divided, the separation being in the line of the axes of the prisms. It was also easy to see that one of the images is nearly, if not quite, unifocal, and the other very decidedly bifocal. I obtained for the index of the ordinary ray 1·63, and for that of the extraordinary 1·49. In the case of calcite these should be about 1·65 and 1·48.

In a section of the shell of *Haliotis tuberculata* occur in the outer layer certain transparent portions, which one might readily suppose were only calcite. This method of study, however, enabled me to prove that they are really aragonite, since certain portions give two well-marked bifocal images. Comparing together all the facts, they indicate that the substance has a powerful negative double refraction and two optic axes not much inclined to one another. The observed indices were 1·71, 1·69, and 1·55, the mean being 1·65. That for aragonite is 1·63, which is as close an agreement as could be expected from one single set of measurements with a section only $\frac{1}{600}$ of an inch in thickness.

These examples will, I trust, be sufficient to prove that it is possible even now to apply this method of study with success in the case of very thin sections. With improved apparatus and using sections specially prepared, there should be no difficulty in obtaining excellent results.

II.—*Description of Professor Abbe's Apertometer, with Instructions for its Use.* By CARL ZEISS, of Jena.

(*Read before the* ROYAL MICROSCOPICAL SOCIETY, *by* JOHN E. INGPEN, ESQ., *December* 5, 1877.)

PLATE II.

THE apparatus in question is intended to enable an exact measurement of angular aperture of any object-glass, dry or immersion, to be made, and to afford a definition of aperture, which is not limited by the maximum air-angle, which is independent of the medium in front of the lens, and which at the same time, by its theoretical signification, may afford a direct indication of the resolving power of an objective.

The principle of the method is stated by Professor Abbe in the following manner:—The lens is made to act as a telescopic objective by combining it either with the naked eye or with an auxiliary microscope equivalent to a terrestrial eye-piece, and by observing the images of external objects near the *back* focal plane of the lens. The angular field of the miniature telescope established in this way, is determined by observation, the real area of field in the microscopic action of the lens, or the central part of this area, being made to act as the area of aperture in telescopic vision. By this inversion the angular *field* in the telescopic action of the lens is made strictly identical with the angular *aperture* in its microscopic action. In order to get a determination of aperture not depending on the medium in which it is observed, the angular amount of the telescopic field is reduced, by a calculated scale, to a purely numerical value—the product of the sine of semi-aperture with the refractive index of the medium in which it is observed. This product is constant for different media (air, water, or balsam), and by its value in any objective indicates the limit of resolving power (the minimum distance of separable parts) in relation to the wave-length of light.

The apparatus consists of a semicircular disk of crown glass, 90 mm. (3·5 inches) in diameter, and 12 mm. (0·5 inch) in

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DESCRIPTION OF PLATE II.

FIG. 1.—Plan of *Apertometer*, full size. *a*, silvered cover with transparent centre; *b*, *b*, blackened brass indices. The inner scale shows the air-angle, the outer scale the "numerical aperture," by which a direct comparison can be made between dry and immersion objectives.

FIG. 2.—Elevation, showing position of one of the indices *b*. The image of the point is made to coincide with the margin of the field of view.

FIG. 3.—Section of examining glass, showing the position of its achromatic lens and diaphragm.

FIG. 4.—Diaphragm of examining glass.

FIG. 5.—One of the indices shown in perspective.

thickness, polished on the cylindrical edge, and ground to an angle of 45° in the direction of the diameter. This disk being put on the stage of a microscope, the rays admitted by the cylindrical edge of the disk horizontally are directed into the axis of the microscope by total reflexion. The centre of the semicircle is formed by a little hole in a silvered cover cemented to the upper face of the disk.

Two indices of blackened brass with sharp edges, sliding on the periphery of the disk, afford visible marks for observing the limits of telescopic field, or microscopic aperture, of any objective.

On the upper face of the disk there are two engraved scales; one of them showing the angular semi-aperture for air, the other the numerical indication of aperture as stated above.

A 2-inch object-glass, with a specially adjusted diaphragm above the lens, is added to the apparatus. It is to be adapted to a draw-tube applied within the microscope, in order to get the telescopic eye-piece necessary for measuring the higher power objectives.

The management of the apparatus is as follows:

The semicircular disk of crown glass is to be put on the stage of a microscope, and the objective, the aperture of which is to be measured (we will call it x), is roughly focussed to the little hole in the silvered cover-glass. In the case of an immersion lens a drop of water of course will be applied.

This done, the eye-piece of the microscope is taken off, without altering the position of the objective x. The naked eye, in looking down into the open tube, will now see above the objective a small air-image of the cylindrical edge of the glass disk and images of objects round the microscope, which are brought into the axis of the microscope by total reflexion.

If x is an objective of low power, from $\frac{1}{2}$ inch downwards, the naked eye is sufficient for observing the aperture. For this purpose the two indices of black brass are put to the edge of the glass disk, and moved to and fro until the points of them as seen in the image above x just touch the margin of the illuminated field; i. e. appear or disappear, the pupil of the eye being kept in a central position. The position of the indices is read by their straight edges on the innermost scale of the disk. The half sum of both readings will give the semi air-angle of the objective x. For systems of higher power the image above the objective is too small for observation with the naked eye. In this case an auxiliary microscope is necessary for this observation, which is got by means of the draw-tube. The lens belonging to the apparatus (we will call it B) is screwed to the draw-tube and combined with one of the ordinary eye-pieces. The auxiliary microscope thus obtained, is focussed to the image above named, by moving the draw-tube up and down until the edge of the disk is seen quite distinctly. Now the indices are adjusted, as before described, so that their sharp points just touch the margin of the circular field limited by the contour of the back lens of, or any diaphragm in x. If the aperture is great enough, the indices should be brought to the disk in such a position as to touch the margin from *within*.

The position of the straight edges of the indices on the *internal* scale of the disk will give the *semi* air-angle of the objective x, as stated before. The external scale will give another definition of the aperture which is more abstract, and may be applied to those immersion lenses the angular aperture of which, taken in air, would surpass 180°; i.e. would be imaginary. This external scale will give the value of the product $a = n \,.\, \sin.\, w$, n denoting the refractive index of any medium in front of the objective, and w the angle of semi-aperture belonging to the same medium. This quantity a, which Professor Abbe calls "numerical aperture," gives an absolute definition of aperture, which will not depend on the nature of the medium, supposed in front of the lens—air, water, or balsam; and by which lenses of every kind are directly comparable. This value, taken note of as above described, the middle of the readings of both the indices considered, will afford the angular semi-aperture w of the lens for any definite medium, by the formula

$$\sin.\, w = \frac{a}{n},$$

a denoting the number observed, n the index of the supposed medium.

For instance, the immersion lenses of Zeiss will give approximately,

$$a = 1{,}1;$$

calculated for water ($n = 1 \cdot 333$), for balsam ($n = 1 \cdot 50$),

$$\begin{aligned} \sin.\, w &= \frac{1{,}1}{1 \cdot 33} & \qquad \sin.\, w &= \frac{1{,}1}{1 \cdot 50} = 0 \cdot 733 \\ w &= 55^\circ\ 30' & w &= 47^\circ\ 15' \\ 2\,w &= 111^\circ & 2\,w &= 94^\circ\ 30' \\ &= \text{water angle.} & &= \text{balsam angle.} \end{aligned}$$

The internal scale gives the semi air-angle from 5-5 degrees, the external scale the value of a from 5–5 units of the second decimal; by estimate the single degrees and the units of the second decimal of a are easily deduced.

The exactness of the observation does not depend either on a very exact focussing to, or an exact centering of the hole in the silvered cover (the centre of which forms the geometric centre of the scales). It is sufficient if any point whatever of the hole is in the field of vision of the objective *x*, the possible difference of centering being eliminated by taking the mean of the reading of both indices.

It is important in this method of measuring that, by the arrangement described, all "false rays," i. e. all rays which do not act in the formation of the ordinary microscopic image, which the objective *x* would produce, are excluded. If the observation is made with the naked eye, the pupil of the latter (which by its central position at the end of the tube will coincide with the ordinary image as seen in the eye-piece) acts as a diaphragm for this purpose. In the case of the auxiliary microscope the same effect is produced by a diaphragm above the achromatic lens, belonging to the apparatus. In observing the indices on the disk by the auxiliary microscope, this diaphragm excludes *all rays besides those* which would form the ordinary microscope image *in the middle part of the field of vision.* Therefore this diaphragm forms an essential part of the apparatus, and must be specially adjusted to the objective B, in diameter and position, in order to fulfil its task.

In the two scales the position of every line has been calculated, the calculation being based on the measured index of the crown glass forming the disk.

FOREIGN MICROSCOPY.

On the Orthonectida, a new Class of Animals parasitic on Echinodermata and Turbellaria. By M. A. Giard.*—The little Ophiuran, *Ophiocoma neglecta*, contains a singular parasite which may serve as the type of a whole group of animals of very curious organization and hitherto almost unknown. The following are the circumstances under which this parasite is met with. *Ophiocoma neglecta* is an Ophiuran with condensed embryogeny, or viviparous. The incubatory cavity, situated in the aboral part of the disk, communicates freely with the exterior; for the most advanced embryos contained in this cavity frequently present upon their arms a pretty *Vorticella*, which occurs almost always upon the arms of the parent animal. On tearing open the disk in order to extract the embryos from it, we find it, in certain individuals, filled with a multitude of animals like large ciliated Infusoria, which traverse the field of the microscope in a straight line, and with the rapidity of an arrow. The animals occur of two forms, which I shall name provisionally the *elongated* and the *ovoid form*. In both they are simple *planulæ*, that is to say, organisms composed only of two layers of cells—an exoderm or outer layer of ciliated cells, and an endoderm consisting of larger cells bounding a linear central cavity with no buccal aperture or anus. Notwithstanding this low organization, the body is metamerized, and the metameres even present remarkable differentiations. The first ring terminates anteriorly in a blunt cone, and bears a tuft of rigid setæ. It is followed by a cylindrical ring of the same length, the whole surface of which is roughened with papillæ, apparently disposed in ten longitudinal rows; this is the only part of the body which does not present vibratile cilia. The third ring is larger than the first two taken together; it widens gently towards its posterior extremity. The fourth metamere is of the same dimensions as the papilliferous ring, it is followed by a terminal ring, furnished with longer cilia at its posterior extremity, conical and subdivided into two metameres less distinct than the preceding ones. Such is the elongated form. The last rings form a sort of club with which the animal beats the water, independently of the movement of the cilia, and by sudden blows, which one might think due to the action of muscular elements. The ovoid form differs from the elongated form only in its less length and greater breadth; but I have ascertained that it is not the result of a contraction of the animal. Perhaps it is a sexual form, perhaps also a young state of the parasite. I give this strange animal the name of *Rhopalura ophiocomæ*.†

Intracellular Fermentation.—In a note communicated to the French Academy by M. Muntz, reference is made to experiments of MM. Lechartier and Bellamy showing that fruits, roots, and leaves

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* From the 'Annals and Magazine of Natural History' for February, 1878.

† 'Comptes Rendus,' October 29, 1877.

removed from the action of oxygen became the seats of alcoholic fermentation with evolution of carbonic acid, and without the appearance in their tissues of any alcoholic fungi. These observations confirm the statements of Pasteur in 1861, that if plants continued to live in an atmosphere of carbonic acid they became ferments for sugar and behaved like beer yeast. M. Fremy thought that the true explanation was that yeast cells were formed, and to settle this question M. Muntz made his experiments, and found that the plants he grew in air produced no alcohol; that those grown in nitrogen afforded appreciable quantities; and the plants continued to develop. He did not search for mycoderms, but assumed none were present, because the plants began in a few hours to produce oxygen and preserved their vitality, which he considers they would not have done had they been invaded by fungi. To detect minute quantities of alcohol he employed Lieben's method, which depends upon the action of iodine and an alkali at a slightly elevated temperature upon alcohol. It gives rise to iodoform (a yellow solid), the production of which he watched under the microscope. He supports the conclusions of Pasteur that the living cells of the higher plants can in the absence of oxygen act like fungus cells and produce a true alcoholic fermentation.*

The Inversion of Sugar by Fungi.—M. Gayon states to the French Academy, as the result of his observations, that *Penicillium glaucum*, *Sterigmatocystis nigra* (*Aspergillus niger*) rapidly invert sugar solutions, but other Mucors, such as *M. spinosus*, *M. mucedo*, *M. circinelloides*, *Rhizopus nigricans*, leave them intact. The unicellular plants Pasteur calls *torulas*, act also as inverting ferments. When the mucors are obliged to live without free oxygen in the must of beer or wine, their mycelium becomes chambered and develops ferment cells, which reproduce themselves in the same form while the conditions are unchanged, but develop in the normal state when replaced in very aerated liquids. The ferment cells of *Mucor circinelloides* are spherical, and remarkable for activity of pullulation. In solutions of levulose, or glucose, the alcoholic fermentation proceeds as in beer must, but in cane-sugar solutions no such action occurs, as the sugar is not inverted by the mucors mentioned. M. Trécul, commenting upon these observations, concluded that those observers were right who affirmed that *P. glaucum* could pass into the form of beer yeast and return back to its original form, which M. Pasteur denied. M. Pasteur, in reply, referred to his 'Études sur la Bière' as confuting this idea.†

Formation of Blood Fibrin.—M. Hayem described to the French Academy microscopical studies on this subject. He states that the bodies he calls *hæmatoblasts*, which can be recognized in living animals, experience great alterations when they pass out of the vessels. He states that when a preparation of coagulated frog's blood has a current of iodized serum passed through it the "hæmaties" may be seen disposed in rosettes around masses of hæmatoblasts, fixed in their positions by filaments springing from the centre of the

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* 'Comptes Rendus,' January 7, 1878.

† Ibid.

rosettes. This mode of treating the blood displays the hæmatoblasts transformed into irregular, angular, stellate corpuscles, with extremely fine delicate fibrils springing from them, branching and forming a network not easily seen, except they are coloured with iodine. Human blood exhibits these changes very plainly. The hæmatoblasts of the ovipora, like those of the higher vertebrates, experience rapid modifications. A few minutes after the preparation is made they become much changed, and may be seen in the interspaces between the hæmaties as little corpuscles, mostly spinous, isolated, or grouped in chaplets; afterwards in small irregular masses. These corpuscles are in general more highly refractive than the hæmatoblasts that form them, and are often of a greenish yellow colour. If blood is taken from a living animal and diffused through enough iodized serum to hinder coagulation, the hæmatoblasts appear isolated and in their normal shape, but after some hours they exhibit small prolongations that seem formed of their own substance. In defribrinated blood neither hæmatoblasts nor their corpuscles are found, and this is the case with blood taken from a dead body after *post mortem* coagulation. The hæmatoblasts, as well as being destined to become adult red globules, possess special properties, and may be considered as a third species of blood elements. Are they the determinating cause of coagulation? This seems probable. At any rate, three factors are concerned in coagulation; a substance proceeding by exosmose from the hæmatoblasts, and which perhaps represents paraglobulin; isolated or grouped corpuscles formed by them in the process of cadaveric change, and from which the network of fibrils springs; and a substance primitively dissolved in the plasma, modified in the presence of the matter exuded by the hæmatoblasts, and forming by precipitation nearly all the fibril network. In their normal state the smallest hæmatoblast corpuscles are about 1 μ in diameter, and the largest rarely more than 8 μ. In intense anæmia, especially when allied to a cachectic condition, we see voluminous masses formed by the hæmatoblasts 60 or 70 μ in their largest diameter, but usually the network springing from them is less than in the normal state. In acute maladies, the hæmatoblasts are less abundant, but, contrary to what is observed in cachexies, the fibrin forms a rich and thick network.*

Action of very Low Temperature on Bacteria.—While the action of high temperature on bacteria has been frequently studied, few observations have been made as to their behaviour at low temperatures, but it has been found that they stiffen at 0° (C.), and are not killed at − 18° to − 25° (C.). Herr A. Frisch by means of solid carbonic acid and ether exposed some putrefactive fluid bacteria and some forms of coccus and bacterium in the morbid products of living organisms to − 87·5°, and allowed them in the course of 2½ hours to rise to 0°. The result was that the bacteria in the fluid withstood this low temperature, and was able to grow rapidly when transferred to a suitable nutritive fluid. Further information is to be given concerning the resisting power of Coccus, Bacterium, and Bacillus.†

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* 'Comptes Rendus,' Jan. 7, 1878.

† 'Der Naturforscher,' 5, 1878.

Chrysalis Mimicry.—A species of butterfly in Venezuela observed by Gollmer (*Aidos amanda*) makes a cocoon which it fastens to a twig, and which has the appearance of round holes. It is composed of two layers, of which the outer one is perforated, and the inner one so bent in as to leave a hollow space between the two. The chrysalis is protected by the strong inner layer which is not seen from outside, and the outer layer appears bored right through, and looks like the hole left by a species of wasp when it emerges from the pupa state.*

Diatom Desiccation and Revival.—The 'Journal de Micrographie' for December, 1877, gives a paper on this subject by Paul Petit, who states that after vainly searching amongst dried mud containing diatoms for spores or zygospores, he made the following experiments:—He collected at various times of the year diatoms with their substratum of mud, and allowed them to dry in the sun, sheltered from dust; some for six, some for eight months. Last September he examined fragments from these deposits, and found the frustules transparent and seeming empty; but a careful investigation showed that in the interior of a considerable number there were some large brown granules, which he took for desiccated endochrome. The vessels containing them were then filled with distilled water that had been well aerated, and exposed to direct light and heat of the sun. For the first three days little change was noticed, but from the fourth day the brown granules augmented in volume and assumed the yellowish tint characteristic of diatom endochrome. Watching from day to day the increase of the plasma in volume, he noticed that at the end of five days it filled half the frustule, and on the eighth day assumed its characteristic form. The Naviculæ then began their curious motions, and some days later commenced to multiply by division. Some of the frustules did not recover, and this he thought was because they had been dried too rapidly.

Searching for Trichina.—M. Tikhomiroff, in making a microscopic examination of pork supposed to contain this parasite, digests small pieces for half an hour with their weight of chlorate of potash, to which he adds four times as much nitric acid. The muscular tissue thus treated is agitated with distilled water till the fibrils separate. If the trichina is present, a hand lens shows the fibrils with fusiform swellings, and the microscope recognizes the creatures.†

A Fossil Spider.—'La Nature,' January 26, 1878, gives a magnified drawing of a fossil spider, *Attoides eresiformis*, discovered by M. Ch. Brongniart in the tertiary marls of Aix, in Provence. It is about 3·5 mm. long, and allied to the recent Salticus (Attus) and Eresus.

The French Academy has awarded 600 francs to M. Bagnis for a monograph of *Puccinia*, and the Commission to which his work was referred, observe that authors admit more than 370 species of this genus, generally characterized and named according to the plant they infest. This implies that one plant only nourishes one *Puccinia*, and that each *Puccinia* is only parasitic on a particular plant. M. Bagnis

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* 'Der Naturforscher,' 1, 1878.

† 'La Nature,' February 2, 1878.

now shows the contrary to be the case, and that one plant may nourish many distinct forms of *Puccinia*, and that one *Puccinia* may be found on very different plants. He also shows that the grouping of the spots formed by the fructification of these fungi depends more upon the plant that nourishes it than upon the fungus, and that these characters cannot be regarded as specific.

On the Bed-bug and its Allies. By Professor Leidy.—In the western part of our country, observed Professor Leidy, I frequently heard that bed-bugs were to be found at any time beneath the bark of the cottonwood and the pine. In these positions I never found one, nor have I ever found the insect except in the too-familiar proximity of man. Recently, when in the west, while watching some cliff swallows passing in and out of their retort-shaped nests, built under the eaves of a house, I was told that these nests swarmed with bed-bugs, and that usually people would not allow the birds to build in such places, because they introduced bed-bugs into the houses. Having collected a number of the bugs, as well as others from the interior of the house, specimens of both of which are submitted for examination by members, I found that while the latter are true bed-bugs, *Cimex lectularius*, the former are of a different species, the *Cimex hirundinis.*

The bugs infesting the bat and pigeon have likewise been recognized as a peculiar species, with the name of *C. pipistrelli* and *C. columbarius.* Professor Leidy further noticed that the habit of the *C. hirundinis* was similar to that of *C. lectularius* in the circumstance that the bugs during the daytime would secrete themselves in crevices of the boards away from the nests. After sunset he had observed the bugs leave their hiding-places, and make their way to the nests. From these observations it would appear as if the peculiar bugs of the animals mentioned did not reciprocally infest their hosts.*

OBITUARY.

We very much regret that we are unable to give any adequate biographical notice of our late friend, Dr. Lawson. We have done our best to procure some details of his life previous to his residence in London, but have not yet received the promised assistance of our friends in Birmingham, where he was Professor of Physiology at Queen's College.

On coming up to London he was first lecturer on Histology at St. Mary's Medical School, and afterwards lecturer on Physiology and the paid physician. At that time he did some good original work in the anatomy of snails, and denied the existence of an ovotestis. He also, before Günther, proved that whitebait are young herrings. He also wrote a paper on the lungs, heart, and blood-corpuscles of the slug, and others on the anatomy and physiology of gasteropods.

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* 'Proc. Nat. Sci.,' Philadelphia.

Latterly we have all known him well as a member of our Council and Editor of our Journal. He was elected a Fellow in 1868, and became Editor of the 'Monthly Microscopical Journal' when it was first established in 1869.

He continued to perform the editorial duties until his death, on the 4th of October, 1877, in his thirty-seventh year, and his removal from us has led to the entire discontinuance of that Journal, and to the resolution of the Council to publish our own 'Transactions.'

James Scott Bowerbank, LL.D., F.R.S., &c., was born in Sun Street, Bishopsgate, London, on the 14th July, 1797, and received his early education from the then celebrated Dr. Kelly, of Finsbury Square, London.

About the age of fifteen he entered his father's distillery, where in subsequent years, and in conjunction with his late brother Edward, the business was carried on under the name of Bowerbank and Sons.

At this early period his scientific tastes began to develop, leading him to the study of astronomy, chemistry, botany, geology, anatomy, and physiology, which occupied every available moment of his time not devoted to business, which he pursued with ardour, but made it available whenever possible for his scientific studies.

About the year 1820 he joined the old *Mathematical Society* meeting in Crispin Street, Spitalfields, where he attended the lectures of a Mr. Wilson, a name famous at that time. In this Society he was subsequently appreciated as a lecturer on geology, botany, anatomy, and physiology, and his diagrams and botanical models were used at one of the metropolitan hospitals for some years in their lectures.

As a member of the *London Clay Club* he investigated the fossil fruits and seeds from the Isle of Sheppey, and in 1840 began their history; but this publication was not continued. 180,000 fruits and seeds are now in the British Museum as a result of his industry in collecting. Out of this gathering of earnest workers came the "*Palæontographical Society*" in 1847—a Society which has done so much to make known the richness of the fossils of our own country, having figured 22,754 specimens, and described 4444 species in 30 volumes.

For many years Dr. Bowerbank was its Hon. Sec.; for ten years, and at the time of his death, its President.

Entomology was a favourite study of his in early days. He wrote a valuable paper in the Entomological Magazine, 1833, on "the Structure of Scales on the Wings of Lepidopterous Insects." He had also observed the circulation of the blood in the larvæ of *Ephemera marginata*, and many other matters too numerous to mention here.

The microscope was his especial delight and study, and by its use his investigations into the structure and habit of sponges, both recent and fossil, have been greatly facilitated, and brought to a state of comparative completeness.

Bowerbank was one of the originators of the *Royal Microscopical Society*, and had filled the office of President. He was also a contributor to its 'Transactions,' and in the Journal for June 1st, 1870, may be found his account of the early improvements made in the microscope in 1828 by Tully, and afterwards by Ross, Powell and Lealand, Smith, and Beck; also on the methods of mounting objects by the use of Canada balsam.

Indeed, so many eminent men came at this time to his house in order to examine their specimens by his instrument, that he was compelled to fix one night in the week for their reception, and thus originated the celebrated "*Monday Night Meetings*," where so many eminent men used to assemble, and always received a kindly greeting and welcome, whether in the New North Road, Park Street, Islington, or in his capacious museum at Highbury Grove.

A Fellow of the *Geological Society* as early as 1838, he wrote a paper in the 'Annals and Magazine of Natural History' on "Organic Remains in the Flint of Chalk," and in 'Trans. Geol. Soc.' vol. vi. 1841, on "Siliceous Bodies of the Chalk, Greensand, and Oolites."

He also formed a large collection of fossils, very many of which now enrich the national and other collections.

Dr. Bowerbank was one of the originators of the *Zoological Society*, and for many years a member of its Council.

In his museum at Highbury Grove the first idea of an *aquarium* was started. A small glass jar was used to keep *Chara translucens* for microscopical purposes, to which were afterwards added some fish and animalcules, until at length the idea was worked out by Mr. N. Ward, Mr. Warrington, Mr. M. Marshall, and others, and brought to its present state of development.

As a *Fellow of the Royal Society* he in 1857 contributed several papers on the "Anatomy and Physiology of the Spongiadæ;" but as a member of the *Ray Society*, which, with the late Dr. Johnston, he assisted in founding, and of which he was for many years Treasurer, he will be best known and remembered for his "*Monograph of the British Spongiadæ.*"

It was in the year 1841 when occurred a fortunate opportunity which gave a bias to his future studies of the sponge, and then first began his really great work.

At Brighton a storm had thrown upon the beach vast quantities of seaweed and sponge as far as the eye could reach. Although dead, they were filled with the soft matter of the sponge. He selected the most promising specimens, placing them in glass jars filled up with strong spirit, and had them immediately conveyed to London for systematic examination, and from these he derived more information than from many times their number of dry specimens.

Having agents on many parts of the coast collecting fossils, he now also employed them in collecting sponges.

Friends in different parts of the world made consignments which were of the utmost value to him in his investigations. His general instructions were, "Only remove as much of the watery matter as will prevent the sponges from rotting on the voyage; but do not send me clean specimens, as if intended for the bath."

The accumulations of years, numbering very many hundreds, are now in the British Museum.

Dr. Bowerbank was a Fellow of the Royal and nearly all the other scientific societies of London. He died at St. Leonards-on-Sea, the 8th of March, 1877, in his eightieth year, after an illness of a little more than a month's duration, and was buried in the family vault at Hollington Church, near Hastings.

CHARLES TYLER.

PROCEEDINGS OF THE SOCIETY.

KING'S COLLEGE, *December* 5, 1877.

H. C. Sorby, Esq., F.R.S., President, in the chair.

The minutes of the preceding meeting were read and confirmed, donations announced, and the thanks of the Fellows were unanimously voted to the donors.

The President said it would perhaps be desirable that he should make an announcement as to what had taken place that evening at the meeting of the Council, with reference to the Journal. On account of the death of Dr. Lawson some difficulties had arisen, and Mr. Bogue proposed terms which it was out of the power of the Society to entertain. The matter had been thoroughly discussed by the Council that evening, they having met at six o'clock specially for the purpose; and after going into the question in all its bearings, it had been decided that the Society should publish its own 'Transactions' from January next. They thought that this plan would offer some advantages to the Fellows, and would be altogether more in accordance with the dignity of a Society like theirs. A committee had therefore been formed to carry out the new scheme.

Mr. J. E. Ingpen then read a paper by Herr Zeiss, "On Abbe's Apertometer," which was illustrated by the exhibition of the apparatus and by drawings made upon the black-board. (The paper will be found printed at p. 19.)

The President, in moving a vote of thanks to Herr Zeiss, said he had been obliged to pay some attention to this subject of angular apertures, and he felt much dissatisfied so far as his experience went, from the want of similarity in the results obtained by different methods. He thought it would be exceedingly interesting to know how far the new method agreed with the others. He suggested that it would be well to stop off the front lens of the objective by diaphragms of different sizes, so as to ascertain whether by so reducing the front they would obtain results which were consistent with those obtained in other ways. He would impress upon those who were interested in the subject, the desirability of commencing with low powers, and gradually working up through the series to the high ones. He might just add that the question was one which had been forced upon his notice by certain calculations of Professor Stokes, which caused him to try and see if the apertures as measured in different ways would give differences sufficient to account for the discrepancies observed.

Mr. Ingpen wished to say a few words, by way of supplementing what he said after reading Mr. Wenham's paper on his new method of measuring apertures. Since that time, he had seen Mr. Wenham's way of doing it, and would endeavour to explain it more clearly than he had been able to do on the former occasion. In measuring the angle, Mr. Wenham used the object-glass without any object upon the stage, and having placed the instrument in a horizontal position, he marked off a circle having the objective in its centre; he then put over the eye-piece an achromatic observing lens, and placing a light on a level with the objective, he turned the instrument round until the light began to disappear. Having measured the arc, and marked it as zero on the circle, he turned the instrument round in the opposite direction until the light began to fade on that side; this so far was the ordinary way of measuring the angle. But then at this point he took a brass cap with a very minute hole in the centre, and put it over the eye-piece, and it was at once found that the small pencil of rays which could alone get through this hole was much less than those which got into the whole tube. He took a new $\frac{1}{10}$-inch objective and tried to measure its angle in three ways; in the old way it showed as 125°, then on looking at it with an observing lens it seemed about the same; but the moment the cap was put on, down came the angle to 100°, and Mr. Wenham said that this was the true critical angle of the glass. The principle upon which the cap was used was then explained by means of black-board drawings, and it was shown that through the small hole they got the central pencil of rays which passed through the objective—not of course all that went through the front combination, but all that would pass through the lenses as observing rays.

Mr. Slack asked if Mr. Ingpen had compared the readings obtained in the new way with those obtained by Mr. Wenham's method.

Mr. Ingpen said he had not yet had time to do this, having only received the apparatus on the previous evening; but he had found that it did reduce the angle, although he could not say to what extent.

Mr. Stephenson, in reply to a question from the President, said that Professor Abbe had shown him the apparatus when he was in London, at the Exhibition of Scientific Instruments at South Kensington. Professor Abbe on that occasion tried several objectives; the lowest of these was Zeiss's No. 2 immersion, which gave 105°, No. 3 gave about 102°. It seemed to him to be a very excellent way; on the occasion to which he referred the slab of glass was rather different from the one now exhibited, being square instead of half circular.

Mr. Slack asked Mr. Stephenson if the measures taken by his own plan differed much from those obtained by Mr. Wenham's.

Mr. Stephenson said he had never tried Mr. Wenham's method, his remarks referred entirely to Professor Abbe's.

Mr. Ingpen pointed out that it was decidedly essential that every circle should be most accurately calculated, and that a different correction was necessary in the case of every plate in consequence of differences in the refractive indices of the glass of which they were made.

Mr. Slack then read a paper by Mr. F. A. Bedwell, "On *Cephalosiphon.*" The paper was illustrated by drawings, some of which were enlarged upon the black-board by Mr. Stewart. Mr. Slack, in referring to the diagrams, explained briefly the structure of the rotifer, and showed that the chief point in the paper was that the selective power, which all observers must have noticed to be possessed by this class of creatures, was in some way or other connected with the "tongue."

The President moved a vote of thanks to Mr. Bedwell for his communication, remarking at the same time upon the difficulty of following papers of this kind without having them to read and compare with the diagrams at one's leisure.

Mr. W. S. Kent said that mention was made of the "siphon tube"; he thought that to be really what its name implied, it must necessarily be open at both ends, but he could not make out that this was so. It was apparently a kind of long tentacle thickly fringed with hairs at the end, and seemed more likely to be used as a plasterer's brush than a siphon.

Mr. Charles Stewart read another paper by the same author, "On a New Method of Examining *Actinia mesembryanthemum*;" and at the suggestion of the President, Mr. Stewart by means of a large black-board drawing explained the general structure of this class of sea-anemones, and denoted the chief points of interest referred to in the paper.

The President proposed a vote of thanks to Mr. Bedwell for the paper, which he thought evinced a great amount of work; their thanks were also due to Mr. Stewart for his very clear explanation of the subject.

Mr. W. S. Kent regarded this as a most interesting paper, and one which he felt sure they would appreciate still more when they had an opportunity of reading it. It appeared to contain some rather original discovery, and the mode of examining these creatures was certainly very ingenious, and would enable the merest tyro to examine this species perfectly.

Mr. Charles Stewart said that a specimen found some time ago in a deep-sea dredging from the 'Porcupine' showed that there was not the same contraction of the body walls as was found in most species. It was at first thought to be a *Holothurian.* Mr. Stewart then drew it upon the black-board, and pointed out that a section of it agreed in every respect with a drawing of *Actinia* given by Mr. Gosse. He also mentioned that observations of these deep-sea creatures did not necessarily depend upon vivisection, as recommended in Mr. Bedwell's paper, because the objects themselves were so transparent that all which went on within could readily be seen from outside. In this way the absorption of food might be perfectly watched, and it would be seen that it was not digested in the so-called stomach, but was rapidly passed down into the body cavity below.

The President stated that he had at one time studied some of these creatures in order to ascertain the nature of their colouring matters.

Mr. Stewart said this reminded him that there was a circular band round the mouth, of a beautiful colour, which was due to the presence of hæmoglobin; and it was curious to note that this was the colouring matter of the human muscles, and it was also found in the Odontophores.

Mr. W. S. Kent inquired if the President had paid any attention to the remarkable turquoise bodies found upon Actinia, and which was also found in a jelly fish, also in a nudibranch, and in a marine Cyclops and some others.

The President said it was a number of years since he investigated these subjects, and although he believed that he did examine a blue colour amongst others, he was not prepared to say off-hand, as he was unable to recall the observation with sufficient distinctness. He was, however, quite impressed at the time with the idea that there was a wide field of research open in that direction.

The meeting was then adjourned to January 2, 1878.

The following gentlemen were elected Fellows of the Society:—W. L. Scott, Esq.; James Baynes, jun., Esq.; Rev. P. R. Sleeman; and Henry Schlesinger, Esq.

January 2, 1877.

Dr. John Millar, F.L.S., in the chair.

The minutes of the preceding meeting were read and confirmed, a list of donations read, and the thanks of the meeting were voted to the donors.

The chairman reminded the Fellows that in view of the approaching anniversary meeting they would be called upon to elect two auditors of the accounts, and the "House List" of nominations for Officers and Council would be submitted to them.

Mr. W. T. Suffolk, proposed by Dr. Gray, and seconded by Mr. Thos. Palmer; and Mr. R. T. Lewis, proposed by Mr. Curties, and seconded by Dr. Matthews, were then duly elected Auditors.

The Chairman said that with regard to the changes proposed in the list of Officers and Council, the President would retire, and it was proposed to elect as President Mr. H. J. Slack. Two of their Vice-Presidents would retire, and in their places it was proposed to elect Dr. Hudson and Mr. Sorby. Their present Treasurer would be invited to retain his office, and as Secretaries they had nominated Mr. Charles Stewart and Mr. Frank Crisp. The four members of the Council who would retire were Messrs. Crisp, Ingpen, Loy, and Dr. Lawson, and it was proposed to elect in their places Messrs. Badcock, C. J. Fox, Dr. Gray, and Dr. Matthews.

A paper by Dr. Bartlett, "On the Detection of Toxic Matter connected with Typhoid and other Enteric Diseases," was read by the Secretary, and the thanks of the meeting were unanimously voted to the author for his communication.

Dr. Bartlett, in reply to a question from Mr. Slack, said that the "fungus" formed in the first instance was merely an ordinary sac or cell, after a short time it became elongated and threw off a filamentous material (like that shown by some of the bacteria) with a number of spores, and it seemed to him to be a sort of connecting link between vegetable growth and that of animal matter. It was not easy to give a very satisfactory idea of them by describing them only, but he hoped shortly to be able to show some very elaborate drawings which would render the subject much more clearly than any verbal description. He believed that Dr. Klein was the first to discover these bodies in the typhoid patient. Whatever it might be, it seemed of precisely the same nature as that which was found in cheese when it was throwing off the butyric ferment. That which he found in the water went through precisely the same stages (and was, perhaps, better identified in so doing) as that found in the cases of typhoid. He had also examined many specimens since, and had been able to identify them so clearly that he was more than ever confident that the two things were identical, and *sarcina* was so well marked that no one would be able to mistake it when seen of a smaller size. The chief difficulty in observing the objects arose from their diaphanous nature, which prevented them from being easily seen, and this led to the suggestion of injecting the organisms with something which would kill, and at the same time would colour them, and this was readily done by a small portion of the mercuric iodide. The point of course was that by adopting this means it had been possible to detect what had entirely escaped the chemical tests which were applied.

Mr. Charles Stewart said that if he had rightly understood the paper, it endeavoured to show that a special fungus found in typhoid patients was due to certain spores found in the water with which the milk cans had been cleansed. He thought, however, that it was hardly possible to say precisely that the fungus in question was the actual cause of the disease, unless it were practically tested whether the introduction of it into the human system was sufficient to produce the disease. These minute fungi were so abundant everywhere, that the mere presence of them where they were found did not of necessity show them to be the cause of the disease, but only perhaps that they had there found a suitable material in which to propagate themselves. Allusion had been made to Dr. Klein's discovery of these fungi, but he believed that although Dr. Klein had thought at one time that he had so discovered them, he had since seen reasons for modifying his opinion, and now was under the impression that the peculiar fine fibrillæ which he had observed were those of fibrine separated from the general structure, and were, in fact, not fungi at all. Dr. Klein, therefore, had given up this particular fungus, but whilst doing so he did not by any means give up the idea that the disease was due to a fungus, and although he had not yet demonstrated its presence in the human subject, he believed that he had shown it in the pig.

Dr. Bartlett said he had not in any way attempted to do more than identify the existence of the fungus in the water, and afterwards in the patients.

The Chairman inquired if the people at the farms had suffered in any way from drinking the milk, or whether they had been in the habit of drinking the water.

Dr. Bartlett said that there had been no appearance of the disease at the farms, and there was no need for them to drink the water from the pond, because they had an abundant supply of remarkably pure water obtained from the deep chalk. The water from the pond had only been used to wash out some of the cans, and for the probable reason that it was less trouble to use it than to draw up the well water for the purpose.

Mr. Slack said that this Crenothix bore a great resemblance to a minute form of bacterium found in the blood of cattle attacked by a splenic disease which the French called *sang de rate;* and with reference to this it had been shown that if any of the blood from an animal so affected was injected into the circulation of a healthy animal, it was the means of reproducing the disease. With regard to Mr. Stewart considering all these things as fungi, he was inclined to think that this was a very difficult thing to decide; for instance, they would find in mother of vinegar a great many bodies which could hardly be classed as fungi.

Dr. Bartlett thought that it was evident that the very minute red bodies which were found there were real parasites on the yeast plant.

Mr. Slack said he did not refer to these red bodies, but to those producing or connected with acetous fermentation.

Dr. Bartlett said it was on account of the growth of these parasites that brewers found it necessary to change their yeast every year or two, otherwise there was danger of getting, in place of a fermentation, merely certain putrefactive changes.

Dr. Matthews asked was there any suspicion of any sewage having found its way into the water in any way?

Dr. Bartlett said that no trace of any sewage was found.

Dr. Matthews thought that if the disease had really been so traced to its origin, and had been shown to thus originate *de novo*, it was of extreme interest, because it had always been thought to be perpetuated and transmitted down through countless generations and to be traceable to contamination with the matter so transmitted.

Mr. Slack said it would be remembered that at one of their scientific evenings he had exhibited a piece of bone from one of the large fossil reptiles discovered in Sussex, the *Megalosaurus Bucklandii;* and Mr. Stewart on seeing it, observed that it very strongly resembled the structure of bird bone. He had brought the specimen with him to the meeting, and also for comparison a section of the femur of a turkey, and would place the two under the microscopes upon the table for comparison, when it would be at once seen that there was a very close resemblance between the forms of the Haversian canals in the two specimens.

Mr. Charles Stewart said that the resemblance to the bird structure in these great bird-like reptiles of America had been already pointed out, and attention had been called to the subject also by Professor Huxley. Certainly, looking at it from a Darwinian point of view, this resemblance was rather striking, and would seem to point to a closer relationship between the two forms than now appeared, and might seem as if they were twigs which had forked asunder from a common origin. Mr. Stewart then, by means of coloured drawings upon the black-board, pointed out the difference between the structure and nutrition of bone in mammals and birds, and showed the similarity of the latter to that which appeared to have existed in the case of the bones of megalosaurus. He believed that attention was first called to these now well-known facts by the late Dr. Bowerbank.

Mr. Slack said he might mention that sections of recent reptile bones did not show the analogy so plainly.

Mr. Stewart thought it most likely that such massively ponderous animals as those must have been required as light a structure of bone as possible to facilitate their movements.

George Peters Price, Esq., was elected a Fellow of the Society.

King's College, *February* 6, 1878.

Anniversary Meeting.—H. C. Sorby, Esq., F.R.S., President, in the chair.

The minutes of the preceding meeting were read and confirmed, a list of donations was read, and the thanks of the meeting were voted to the donors.

At the request of the President, Mr. Curties and Mr. Glaisher consented to act as scrutineers at the ballot for the election of Officers and Council for the ensuing year.

The Treasurer submitted his Annual Statement of the Accounts of the Society, which had been duly audited by the gentlemen appointed at the previous meeting. This and the Report of the Secretaries will be found below.

It was moved and seconded " That the Reports of the Treasurer and Secretaries be received and adopted, and that they be printed and circulated in the usual manner."

The motion having been put to the meeting by the President, was carried unanimously.

The Secretary then read obituary notices of two deceased Fellows —Dr. J. S. Bowerbank and Dr. Henry Lawson.

The Secretary said that as some reference had been made to the discontinuance of the 'Monthly Microscopical Journal,' it might be well for him to say a few words in explanation of what had recently occurred with respect to it. The Council had received from the Publisher a notice that, as he had for some time past carried it on at a loss, he could not continue his arrangement with them, unless at a considerably increased charge to the Society; by this, and also by a reduction in the editorial expenses, he thought he might be able to make it pay. The Council decided that the terms were such that they could not entertain them, for they already paid 20*l.* per month, and they had thought that the advantages offered by the Journal—especially as regarded information as to foreign microscopical work—were hardly so great as they ought to be. For many years past a wish had been expressed by many Fellows that the Society should publish its own 'Transactions,' and the Council fully hoped that they might be able not only to do this, but also to give a good deal of other valuable matter relating to microscopical science.

The President then delivered his Annual Address to the Society.

Mr. Charles Brooke begged to propose a vote of thanks to the President for the very able Address which they had heard read. It was quite clear that in opening up an entirely new branch of microscopical research, it could only be done in outline; but so far as he could judge, the paper opened out many very important and valuable considerations, which were well worthy of their attention. He would add to the terms of the proposition the request that the President would allow the Address to be printed and circulated with the Report in the usual way.

Mr. James Glaisher had great pleasure in seconding the motion. He had listened with much interest to the Address, which was full of facts new to him, and, as the subject itself was a new one, he regarded it as one eminently fitted to be brought before the Society upon an occasion like that.

The motion was then put to the meeting by Mr. Charles Brooke, and carried unanimously.

The President said he felt much obliged to the Fellows for the kind manner in which they had received his Address; he feared, however, that he had hardly been able to do justice to the subject, though he had at least proved that it was far more extensive than might at first be supposed.

Mr. Glaisher then read the following list of gentlemen who had been elected as Officers and Council for the ensuing year:

President—*Henry J. Slack, F.G.S.

Vice-Presidents—Lionel Smith Beale, M.B.; *Charles Thomas Hudson, LL.D.; Sir John Lubbock, Bart., M.P.; and *Henry C. Sorby, F.R.S.

Treasurer—John Ware Stephenson, Esq.

Secretaries—Charles Stewart, M.R.C.S.; and *Frank Crisp, LL.B., B.A.

Council—*John Badcock, Esq.; William A. Bevington, Esq.; Robert Braithwaite, M.D.; Charles Brooke, M.A., F.R.S.; *Charles James Fox, Esq.; *William J. Gray, M.D.; Emanuel Wilkins Jones, Esq.; *John Matthews, M.D.; Samuel John McIntire, Esq; John Millar, L.R.C.P.E.; Thomas Palmer, B Sc.; and Frederic H. Ward, M.R.C.S.

On the motion of Mr. Sorby, the thanks of the meeting were voted to the scrutineers for their services.

Mr. H. J. Slack having taken the chair, said that he was one of those who regretted that the office of President had not fallen upon a more worthy occupant, but he could only thank them for the honour which they had done him, and say that if anything could be done by him to advance the interests of the Society, it should not be wanting. He would just mention that at their next meeting it was proposed to revert to their old practice of a cup of tea.

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* Those with an asterisk before their names were proposed as new members.

Mr. Sorby said that the Society had done him the honour to elect him as one of its Vice-Presidents, but he feared that owing to circumstances he should be unavoidably prevented from attending the meetings. The Geological Society had elected him as their President for two years, and it unfortunately happened that the meetings of the two Societies almost always took place on the same evening, so that he hoped it would be understood that his absence from their Society was not owing to want of interest in their proceedings, but merely because it was impossible for him to be in two places at the same time.

Mr. Slack said they all appreciated so highly the services of Mr. Sorby, that they should certainly regret his absence; but as it was not possible for him to come himself, he could do the next best thing, and that was sometimes send them a paper.

Donations to the Library since November 7, 1877:

	From
Nature. Weekly	*The Editor.*
Athenæum. Weekly	*Ditto.*
Society of Arts Journal. Weekly	*Society.*
Journals of the Linnean Society	*Ditto.*
Transactions of the Linnean Society	*Ditto.*
Quarterly Journal of the Geological Society	*Ditto.*
Bulletin de la Société Royale de Botanique de Belgique	*Ditto.*
Bulletin de la Société Botanique de France	*Ditto.*
American Journal of Microscopy	*Editor.*
Journal of the Quekett Club. No. 35	*Club.*
The Mineralogical Magazine. No. 7	*Society.*
Sur les Mouvements en Apparence Spontanes des Bulles d'air dans les Niveaux. Par G. van der Mensbrugghe, 1877	*Author.*
Bulletin de la Société Belge de Microscope. Two parts	*Society.*
Smithsonian Report for 1876	*Institution.*
Catalogue of the Diatomaceæ, with reference to the various published Descriptions and Figures. By Fredk. Habirshaw. 1877	*Author.*
Report of Science Conferences, 1876. 2 vols.	*The Science and Art Department.*
Transactions of the International Medical Congress, Philadelphia, 1877	*Author.*
Analisi Microscopica di un Deposito di Diatomee, Del Conte A. F. Castracane	*Ditto.*
Studi Sulle Diatomee, Del Conte Abate Francesco Castracane	*Ditto.*
Popular Science Review. No. 5	*Publisher.*
Proceedings of the Bristol Naturalists' Society, 1877	*Society.*
Transactions of the Watford Natural History Society. Three parts	*Ditto.*
The Progress and Resources of New South Wales. By Chas. Robinson	*Royal Society, N.S.W.*
Journal of the Royal Society, N.S.W.	*Ditto.*
Annual Report of the Department of Mines, N. S. Wales. Two parts	*Ditto.*
Biographia Philosophica. By Benjamin Martin	*Frank Crisp, Esq.*
Sale Catalogue of the Books on Natural History of Sir Joseph Banks. By Jona Dryander. 4 vols.	*Ditto.*
Grundriss der Versteinerungskunde. Von Hanns Bruno Geinitz	*Ditto.*
Opera Omnia. By Francis Bacon	*Ditto.*
Natural History Review. 3 vols.	*Ditto.*
A Möller's improved Diatomaceen Probe-Platte	*Adolf Schulze, Esq.*

Mr. Philip B. Mason was elected a Fellow of the Society.

WALTER W. REEVES,
Assist.-Secretary.

ANNUAL REPORT OF THE ROYAL MICROSCOPICAL SOCIETY.

February 6, 1878.

John Ware Stephenson in Account with the Royal Microscopical Society.

Dr. *Cr.*

1877.	£	s.	d.	1877.	£	s.	d.
To Balance brought from 31st December, 1876	231	6	10	By Cash paid for Journal	207	13	9
„ Half-year's Dividend on 1126*l.* 18*s.* 11*d.* Consols	16	13	11	„ Cash paid for 651*l.* 19*s.* 7*d.* Consols	617	7	5
„ Amount transferred from Charter Fund	96	7	5	„ Rent and Attendance at King's College	62	15	5
„ Legacy under the Will of Charles Lambert, Esq., per John Badcock, Esq.	500	0	0	„ Reporter	9	9	0
„ Half-year's Dividend on 1757*l.* 5*s.* 11*d.* Consols	26	0	7	„ Mr. Reeves' Salary ..	80	0	0
„ Composition Subscription	21	0	0	„ Ditto for Commission ..	11	5	0
„ Annual Subscriptions ..	429	13	0	„ Ray Society for 1877 ..	1	1	0
				„ Fire Insurance	1	4	0
				„ Petty Cash	40	10	0
				„ Instruments	13	11	6
				„ Stationery and Printing	10	0	6
				„ Books	11	1	6
				„ Stamped Cheque-book	0	4	2
				„ Balance remaining 31st December, 1877 ..	254	18	6
	£1321	1	9		£1321	1	9

Invested Capital, December 31, 1877.

£1778 18*s.* 6*d.* Stock in the 3 per Cent. Consols.

Quekett Fund.

£134 1*s.* 3*d.* India 5 per cent. Stock.
£3 6*s.* 2*d.* uninvested interest.

January 31, 1878. Examined and found correct,

W. T. SUFFOLK,
RICHARD T. LEWIS, } *Auditors.*

Report of the Secretaries.

The books and instruments of the Society are in good condition. The objects lent for the Exhibition at South Kensington still remain there at the request of the authorities.

The Society's funds received a valuable addition in the shape of a legacy of 500*l.*, under the will of C. Lambert, Esq., which has been duly invested.

Two scientific evenings were held during the year, with great success as regards the interest of the objects and apparatus exhibited, and the attendance of Fellows. The papers read before the Society have fully maintained their reputation by their importance and range of subject.

The following are the more important works presented during the year:

Transactions of the Linnean Society.
Some Remarkable Forms of Animal Life from the Great Deeps off the Norwegian Coast, part 2nd, by George Sars, from the Author.
The Royal Society's Catalogue of Scientific Papers, vol. vii., from the Royal Society.
Popular Science Review, from the Publisher.
Several pamphlets and papers, as well as the journals of other Societies in exchange for our own.

Books Purchased.

Quarterly Journal of Microscopical Science.
Annals of Natural History.
Proceedings of the Royal Society.
Mycographia Icones Fungorum. Parts 4 and 5.
Sachs' Text-Book of Botany.
Proceedings of the Royal Society. 20 vols.
Sphagnaceæ Britannicæ Exsiccatæ. By Braithwaite.

Apparatus, Slides, &c., Presented.

A Binocular Eye-piece, from Mr. Ahrens.
Fourteen Stained Preparations, from Dr. C. Johnstone, of Baltimore.
Six ditto of Double-stained Vegetables, from W. H. Walmsley, Esq.
150 Slides (various), from the Rev. R. H. Nesbitt Browne.
An improved Möller's Diatomaceen Probe-Platte, presented by Adolf Schulze, Esq.

Apparatus Purchased.

A $\frac{1}{8}$ Immersion and Dry Object-glass. By Messrs. Powell and Lealand.

Eleven Fellows have been elected during the past year.

Four Fellows have deceased during the same period, viz.:

*James Scott Bowerbank, LL.D., F.R.S., &c., elected January 29, 1840; died March 9, 1877.

James Lemoine Denman, elected May 13, 1863; died December, 1877.

Henry Lawson, M.D., elected October 14, 1868; died October 4, 1877.

William Jackson Rideout, elected January 15, 1851; died (?).

JOURNAL

OF THE

ROYAL MICROSCOPICAL SOCIETY.

MAY, 1878.

I.—*On a New Coral, Stylaster stellulatus; and Note on Tubipora musica.*

By Charles Stewart, F.L.S., Hon. Sec. R.M.S.

(*Read before the* Royal Microscopical Society, *March* 6, 1878.)

Plate III.

The interesting papers by Mr. H. N. Moseley on the Milleporidæ and Stylasteridæ,* confirming the view long held by many naturalists, that the former really belong to the Hydrozoa, and showing that the latter (Stylasteridæ) should be referred to the same class, have given special interest to a group of corals long remarkable for the beautiful permanent colour which most of them present. As a probably new species of Stylaster has recently come under my notice, I have thought that a few remarks on it might be of interest to this Society.

I am indebted for the specimen to the kindness of Mr. H. P. Potter, who accompanied Mr. Brassey in his recent voyage round the world. It was given to him at Tahiti, with the statement that it was extremely rare, and only found at one small island in the neighbourhood.

The corallum is of a bright rose colour, especially in the younger branches, the older parts being often more pale. The

DESCRIPTION OF PLATE III.

Fig. 1.—Lateral branch of *S. stellulatus*, showing crowded calicles, some undergoing division. × 25 diam.
„ 2.—Fragment of branch, showing ampullæ. × 25 diam.
„ 3.—Orifice of calicle. × 40 diam.
„ 4.—Vertical section of calicle, showing canals and style. × 40 diam.
„ 5.—Fragment of *Tubipora musica*, the thecæ have been opened in places to show included tube. × 3 diam.
„ 6.—Fragment of tube. × 83 diam.

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* 'Proceedings of the Royal Society,' vol. xxv. p. 93.

branches are usually quite cylindrical, though occasionally flattened at their tips; the general appearance being much like that of *S. sanguineus*, but it has a bluer rose tint, and is at once distinguished by the minute size of its calicles ($\frac{1}{67}$ of an inch) which are usually uniformly and densely scattered over the branches, a few of which only show them to be more abundant at the contiguous edges. Each apparent calicle really consists, as has been pointed out in the papers already alluded to, of a central cup-shaped calyx (which in life bears the alimentary zooid), having an opening in its floor from which a large tube passes towards the interior of the corallum: running throughout the whole length of the tube is a minutely spined style-like columella whose point may be seen in the centre of the hole at the bottom of the calyx. Around the calyx and attached to its outer surface is a series of from ten to fourteen vertical plates, which, although they so closely resemble the septa of an Actinozoan corallum, are really only the remains of the cœnenchyma which separates the individual members of a circle of tentacular zooids that surrounds the central alimentary one. The outer border of these plates is attached to the surrounding cœnenchyma, which is often raised around them so as to resemble the theca of an ordinary coral. The edge of this false theca is sometimes more raised on the proximal side (nearest fixed end of corallum), at other times on opposite sides corresponding with the plane of the branches, but is absent or slightly developed on the larger branches where the axis of the group of zooids is at a right angle to the surface. At some depth between each of the septa may be seen a small, rounded, brightly glittering, and nearly colourless sphærule attached to the theca; much smaller, but otherwise similar ones, stud the larger canals, and are especially evident around the opening through which the style projects. The general substance of the cœnenchyma, although exceedingly hard, is permeated by numerous small and branched intercommunicating canals which open into the main canals of the alimentary and tentacular zooids, and also upon the general surface, which is somewhat raised between them. They appear as white lines on the section surface, as their interior appears to be covered with an amorphous opaque deposit.

Besides the calicles which give the chief beauty to the coral, some of the branches show small rounded or conical elevations (ampullæ) of the surface, mostly situated on the non-contiguous sides of the branches, the apices of the elevations having one or more small perforations. These have been shown by Mr. Moseley to be the chambers in which are contained the adelocodonic reproductive organs. In some cases the elevation is not marked, although the hole is present, which then sometimes has a white spine-like process by its side.

The number of the calicles appears to be increased by fission. In the coral the first indication of this is the appearance of the points of two styles close together. A bridge stretches between the points of the styles. The calicle increasing in size first becomes oval, with an increase in the number of septa; further constriction then completes the separation. I have sometimes seen obscure indications as if at times the calicles might occasionally arise by the simultaneous budding of tentacular and alimentary zooids from the surface of the cœnosarc. The apparent division of the calicles is perhaps really a case of fusion; this is favoured by the fact that the apices of the styles are directed towards one another. But the normal number (thirteen) of the septa is the same in a calicle with two styles, and increases with their separation, until, when nearly complete, they are usually twenty-six. Such an abortion of zooids following fusion does not seem probable.

The chief points in which the corallum of this genus differs from that of the Actinozoan corallum, which it in appearance so closely resembles, are—

That it is secreted by the ectoderm.

That it is permeated by anastomosing canals, which are traversed by tubular prolongations of the body wall corresponding either with the hydrocaulus or hydrorhiza of other hydrozoa (reminding one of the hydrorhiza of Antennularia).

That the calicles are groups of chambers, the central one for the alimentary, the marginal ones for the tentacular zooids.

That the septa are the remains of the cœnenchyma between the tentacular zooids.

And that the theca is but the elevation of the cœnenchyma around the group of zooids.

Although many descriptions of the corallum of *Tubipora musica* have been given, I have not seen a notice of a peculiar feature which I have found present in nearly all specimens examined, but which is particularly marked in one in my own possession. This feature consists in the presence of a second tube averaging about one-third the diameter of the including theca. It is very delicate, and of a pale rose colour; its thin perforated walls appear to be composed of numerous branched flattened spicules having a fibrous texture. The tube is generally connected with the theca at the points where the plates of connecting cœnenchyma are found, either by spreading out here into a funnel-like end or by tubular branches.

In the absence of soft parts, one can only speculate on their real meaning. It seems possible that by them a communication might be kept up between the body cavities of the living zooids on the surface of the corallum and the canals in the tables of cœnenchyma, from which budding often takes place. The remains of the mesoderm and the endoderm having shrunk away from the theca, where its vitality had been lowered. It has been suggested to me that they might be calcifications occurring in the lower border of the stomach (the secondary tubes corresponding with this in diameter), but the branched mode of termination frequently seen does not seem compatible with this.

II.—*An Easy and Simple Method of Resolving the Finest-lined Balsamed Diatomaceous Tests by transmitted Lamplight, with special reference to Amphipleura pellucida.* By ADOLF SCHULZE, Glasgow.

(*Read before the* ROYAL MICROSCOPICAL SOCIETY, *March* 6, 1878.)

THE resolution of the finest-lined tests, and especially of the markings of *Amphipleura pellucida*, is at all times a matter of some difficulty, and requires for its accomplishment the best objectives and the most careful arrangement of the illumination. It is generally assumed that the resolution of the closest markings on diatoms is far more difficult when they are mounted in balsam than when they are mounted dry, and with the ordinary means of illumination this appears to be indeed the case; but I purpose to describe a simple method by which even so small and closely striated specimens as Nos. 18, 19 and 20 on Möller's Diatom-Probeplatte, and other still finer valves, having about 100,000 lines per inch, may be easily and unmistakably resolved into distinct striæ by lamplight, and which by sunlight yields so excellent results that I can only compare them to those admirable photographs of *Amphipleura pellucida* taken by Dr. Woodward. It must, however, be borne in mind that the ridges constituting the markings of these minute diatoms mounted in balsam, possess a minimum of substance, and being extremely transparent, cannot throw *black* shadows such as those of the larger and coarser frustules, and that if the field were too brilliantly illuminated these infinitesimal shadows would be totally obliterated. Some people may be inclined to think that the markings shown as alternate *grey* and white lines are only faintly resolved; but microscopists whose eyes are cultured by observations on diatoms will readily admit such a resolution to be perfect, provided no spurious or coloured lines make their appearance, and they will grant that this is all which can be expected to be seen under the most favourable circumstances.

The best dry achromatic condensers, and even Powell and Lealand's supplementary stage and small plano-convex condenser, fail, as far as I know, to aid in the resolution of balsamed specimens of *A. pellucida;* and those few observers who have succeeded on this difficult test by lamplight have not published any accounts of their modes of illumination.

In an article on the Immersion Paraboloid and the Reflex Illuminator, which appeared in the 'English Mechanic' of 7th December, 1877, Mr. F. H. Wenham claimed as one advantage of the latter over the former that it would give a dark ground on balsamed objects even when they were viewed with immersion lenses. This statement I cannot but consider as only partially correct; and I would like to divide immersion objectives according to their behaviour with the reflex illuminator into three classes: 1stly, those which give a dark ground; 2ndly, those which give a grey ground; and 3rdly, those wide-angled immersion lenses which are capable of giving a light ground, and which alone are suitable for the method I am about to describe.

Some time ago, whilst trying Wenham's reflex illuminator and Powell and Lealand's $\frac{1}{8}$ new formula immersion lens by unmodified sunlight on Möller's Probeplatte, I found on lowering the condenser that the field became brightly illuminated by a spectrum. I focussed for one of the larger diatoms, and found it bathed in spectral colours, which impinged on it very obliquely, and which brought out the markings very distinctly. Bringing successively the finest diatoms of the Platte, such as *Navicula crassinervia*, *Nitzschia curvula*, and *Amphipleura pellucida* in the field, I found all their cross markings revealed with wonderful distinctness, the last-named diatom appearing like a fine comb. These cross markings, for which I had been looking for years, and which had baffled all my efforts to show them, appeared now all at once distinct enough to be counted, and were entirely free from spurious and coloured fringes. I then tried the so-called Edmund immersion paraboloid in the same way, and found that by its means similar but not so satisfactory results could be obtained. The secret of my success was that I had used castor-oil instead of distilled water to unite the top of the reflex illuminator with the under side of the slide, and the former being a thicker fluid than the latter, allowed me to obtain that range for focussing the illuminator which is necessary to obtain light ground. I then experimented with lamplight, and found that the more powerful the light the more distinct the striæ appeared, and that the Dallinger lamp gave the best results; but that even by the light of a lamp having a wick of only half an inch broad, the markings were plainly shown. The illumination obtained in this way, unmodified sunlight included, has the advantage of not being by any means intense enough to be painful to the eyes, and as required, any of the colours of the spectrum may be used without the slightest difficulty. The blue and violet rays are especially agreeable to the eye. The light becomes most dispersed when the narrow side of the wick is used, and when the rectangular prism is turned a little on its vertical axis so that the rays do not fall quite perpendicularly on one of its sides.

Finally, I will give a few practical instructions for this method. I place the lamp to the left, and when using the ordinary form of Möller's Probeplatte, or a slide having a balsamed valve of *A. pellucida* lying horizontally on it, I turn the reflex illuminator so that its polished off face looks as it were to the right, the edge of the wick facing the mirror or rectangular prism at the tail-piece. After having racked up the reflex illuminator until its plane top is level with the stage, and after having centred the dot by means of a $\frac{2}{3}$-inch objective, I put a few drops of castor-oil, or better, of glycerine, which is easier cleaned off by water, on the top of the illuminator, taking care that no air-bells are formed, and that none of the fluid flows down the polished off face. I then illuminate as for dark ground, and focus for the object, generally first for one of the larger diatoms on the Platte, using of course one of those large-angled immersion lenses which I classed among No. 3. By lowering the reflex illuminator or the immersion paraboloid from the one-twentieth to the one-thirtieth of an inch, the ground becomes light, the red appearing to the right and the blue of the spectrum to the left of the field. By a little more focussing of the condenser and adjusting of the mirror or rectangular prism, or by altering the position of the flame slightly, the best result is soon obtained. I invariably use the edge of the flame for throwing light on the mirror or on the rectangular prism, and often I remove the latter altogether and place the flame in the axis of the field lens of the reflex illuminator. A white field is best obtained in this way. Sometimes I place the microscope horizontally on a pedestal from 4 to 6 inches high above the level of the table, and I find this a very convenient position for observing. By interpolating a bull's-eye condenser, convex side towards flame, and by using the broad side of the wick, the prismatic colours disappear and the field becomes white. By turning the microscope a little to the right or to the left on its vertical axis the best illumination is often very easily secured. The light from the reflex illuminator should fall under an angle of about 6° against the midrib of *Amphipleura pellucida.*

The reflex illuminator may also be used for the resolution of lined tests by transmitted light, especially sunlight when the objects are mounted *dry and on the cover.* In this way the lines on *Amphipleura pellucida* can be shown beautifully. I have also found that by transmitted sunlight the reflex illuminator may be used for the resolution of either balsamed or dry lined tests mounted on cover, without the use of any liquid medium whatever between the top of said apparatus and the under side of the slide. The value of this method is not confined to lined diatomaceous tests, but may become of great service for biological and other researches.

The immersion objectives, with which I have succeeded in resolving the finest specimen of *Amphipleura pellucida* in balsam were those of Powell and Lealand's on the new formula, the one-quarter inch included, Tolles', and a series of Zeiss' from the one-eighth to the one-twentieth inch. I find that a power of about 600 diameters is requisite to separate the markings sufficiently, and that with a power of 1000 diameters they become quite visible to anyone, even on the finest specimens, some of which have resisted all efforts on the part of some of the best manipulators to resolve them. I also find a Ross's Kelner C eye-piece very useful for this purpose, as it gives plenty of light.

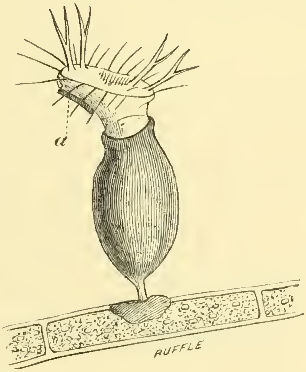
Mr. Wenham's ingenious reflex illuminator, whether if used for the purpose it was originally constructed, viz. for dark ground, or whether if put to what one might call its illegitimate use, viz. for light ground, becomes therefore one of the most powerful means of resolving lined tests mounted in balsam.

III.—*On a New Operculated Infusorian from New Zealand.*

By F. W. Hutton, Professor of Zoology in the University of Otago.

(*Read before the* Royal Microscopical Society, *March* 6, 1878.)

In the 'Monthly Microscopical Journal' for 1869, vol. i. p. 289, Mr. W. S. Kent described, under the name of *Cothurnia operculigera,* an infusorian bearing an operculum. Last November, in a fresh-water lagoon near Dunedin, I found a very similar form in considerable abundance. The New Zealand species, however, differs from *C. operculigera* in having the pedicle much shorter than the lorica, and in the aperture of the lorica being oblique.



Cothurnia furcifer, × 400. *a*, operculum.

In adult specimens the lorica is of a deep chestnut brown, and opaque; it is generally more or less crumpled, but sometimes smooth. The aperture is round, entire, and oblique to the axis of the lorica. The average length of the lorica is $\frac{1}{500}''$. The operculum (*a*) is circular, the same size as the aperture, and of the same colour as the lorica; it is attached to the animal just below the peristome, on that side towards which the aperture slopes. The pedicle is transparent, very short (one-sixth the length of the lorica), or occasionally absent; it is attached at its proximal end to the conferva, on which it lives, by a circular disk of about the diameter of the lorica, and of the same brown colour. The animal is colourless, considerably smaller than the lorica, and attached at the base without any stalk. The contractile vesicle is central. The peristome is surrounded by a moderate number of rather long cilia, which lie nearly horizontally when the animal is fully expanded. Inside these are four much more robust cilia, which are once divided, like a hay-fork. These stand more upright; two are situated just above the operculum, and two on the other side of the peristome. Both these sets of cilia twitch spasmodically at uncertain intervals, but have no uniform motion. Lying internally to these are a set of very short cilia, which are constantly active both when the animal is protruded and when it is withdrawn into its sheath.

In the young the lorica is nearly transparent; and there is no operculum until the lorica is fully shaped out. It then commences to grow, but does not get the full size of the aperture until the lorica has become quite dark coloured. I have never seen two in a lorica.

I propose to call this species *Cothurnia furcifer*, from its four fork-like cilia. The likeness of this infusorian to the capsule of a moss is remarkable.

IV.—*On a Large-angled Immersion Objective, without Adjustment Collar; with some Observations on "Numerical Aperture."* By JOHN WARE STEPHENSON, F.R.A.S., and Treasurer of the Royal Microscopical Society.

(*Read before the* ROYAL MICROSCOPICAL SOCIETY, *April* 3, 1878.)

IN the use of the microscope few things are perhaps more difficult than the effective application of the adjustment collar of a large-angled modern objective.

Not only is the best point of correction difficult to attain, but in too many cases, either because the covering glass is too thick or too thin, the slide is *not suitable*, and it is impossible to do justice to the probably otherwise excellent quality of the lens.

In fact, so indeterminate is the best point, that an objective thrown out of adjustment would seldom be brought back to the identical number on the scale, if readjusted, by any ordinary observer, even on a well-known object.

If this be so, on an object with which one is familiar, how much more difficult must be the examination of an object the structure of which is perhaps wholly unknown.

Such considerations suggested to the writer the great desirability of constructing an object-glass in which cover correction could be entirely dispensed with.

The origin of the correction collar as shown by the late Andrew Ross, was the imperative necessity of compensating the error arising from the difference between the refractive index of the covering glass and that of the air between the front of the lens and the thin cover, whenever a high power was used.

Now it is evident that if some fluid, of which the refractive and dispersive powers are the same as those of the covering glass, were substituted for air in the intervening space, the end in view would be attained.

If, then, such a medium could be found, with, as I said before, optical properties identical with those of the thin cover, it follows that as the distance between the front lens of the objective and the under side of the cover (or the object adhering to it) must, of necessity, be always the same; that is to say, as a thick covering glass would require a thin film of the proposed immersion fluid, and conversely as a thin cover would require a thicker layer (one, in fact, being the complement of the other); the two together would have a constant value, which would be exactly equal to the focal length of the objective.

From this point of view the writer suggested to Professor Abbe the possibility and desirability of the construction of a combination satisfying the conditions named, and that gentleman with characteristic energy at once applied his great knowledge to the solution of the problem, and with complete success.

He informed me that he had already from another point of view considered the propriety of using a more highly refractive medium than water for "petrographic" work (Dünnschliffe), as the thin plates of minerals ordinarily used for microscopic inspection are generally so roughly cut and insufficiently polished that their observation with high powers is very difficult, if not impossible.

The more general problem of constructing an objective in which the necessity for correction, by an alteration of the distance between the lenses, could be entirely dispensed with, was the more attractive to the Professor as the use of a more refractive medium than water enabled him to deal with higher apertures, without loss of definition, than had hitherto been attained. The result of his calculations was the construction by Mr. Zeiss of an objective of excellent quality, satisfying the conditions named and having a balsam angle of 113° = 1·25 of "numerical aperture"; an aperture which is, if I mistake not, larger than any that has been hitherto produced, and one which coincided exactly with the theoretical value given by Professor Abbe's formula. But here an unexpected difficulty arose: it had been assumed by Professor Abbe and myself that amongst the numerous fluids suitable for use, there would readily be found some, pure or mixed, which would give exactly the same refraction and dispersion as crown glass; this, however, proved not to be the case, and the difficulty was not overcome until he had tested no less than sixty-three different oils, and nearly thirty other fluids: he at length ascertained that oil of cedarwood,* although not absolutely identical with crown glass, was admirably adapted for the purpose, giving perfect definition with oblique light, but, for central light, being improved by the addition of one-fourth or one-fifth of oil of fennel seed (*Ol. Fœniculi*). With central light the difference between the spherical aberration of the green and red rays gave, when pure cedarwood oil was used, too much colour, which was corrected by the addition of a small quantity of the more highly dispersive fluid. In the course of these numerous experiments it was found that the tables given by Brewster and Wollaston were *very* unreliable, nearly all the refractive indices given by those authors being considerably too high, and most of the dispersion values too low. As it is probable that further research may still result in finding a more perfect medium than that now used, I may mention that Professor Abbe determines the suitability of a medium by using a bottle, the sides of which are of parallel plate glass, and to whose stopper a small prism of crown

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* The asphalte varnish on the slides can be protected from the dissolving action of the oil by a coating of sealing-wax varnish or gold size.

glass has been fixed. By plunging the prism into the fluid, the refractive and dispersive properties of any oil or mixture of oils can be determined and adjusted by simply viewing the bar of a window through the liquid and the prism.

The qualities of the new objective may be thus briefly described :—

1. There being no aberration to correct for varying thickness of cover-glasses, there is no collar adjustment. For thick covers, say 0·008 to 0·009, the ordinary length of 10 inches gives the most perfect definition ; for thin covers, say 0·004, a length of 12 inches is perhaps better. But the difference is so *very* slight that it is scarcely necessary to use the draw-tube.

2. It has a balsam angle of 113° = 1·25 numerical aperture, which renders it extremely sensitive in focussing, and also indicates the highest resolving power hitherto attained.

3. It has a large working distance. The distance between front of lens and object is 0·02, which gives a working distance of 0·012 for 0·008 cover-glass, 0·016 for 0·004 and so on.

4. Its power is rather more than one-ninth, and having component lenses throughout the combination, larger than in other objectives of the same power, it transmits more light, the latter quality being enhanced by a diminution in the reflection of the peripheral rays.

5. It bears very deep eye-pieces and has a flat field.

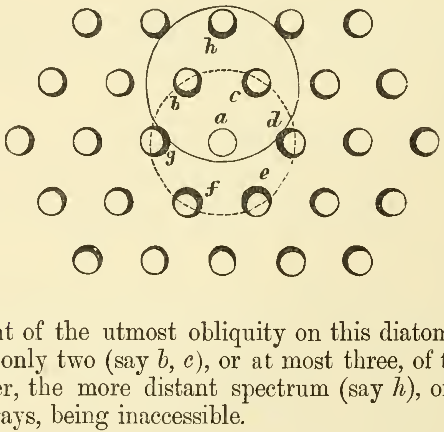
Lastly. An essential condition to its *perfect* performance is that if the object be dry, it must be mounted on, or nearly touch, the cover, or if not a dry object, that it be mounted in some medium having approximately the same refractive index as the oil, such as Canada balsam, &c.

The special advantage of this objective for petrographic work is, that the oil used, having very nearly the refractive index of the objects to be examined, renders cover-glasses and highly polished surfaces unnecessary ; the minerals, if sufficiently translucent, can be observed through a considerable depth, say $\frac{1}{50}$ of an inch, and, on the assumption of identity of index, every plane, from the surface downwards, will have the same perfect correction.

To a certain extent the latter observation applies to all transparent objects mounted in balsam, as the thickness of the balsam above the object may be looked upon as equivalent to a thicker cover, and the penetration must therefore be considerable, although the latter quality will be still greater in the smaller-angled objectives constructed on the same principle, which will hereafter be made.

Professor Abbe, writing to me on the objective, says :—" The advantage of the greater aperture is shown in a most striking manner on *Pleurosigma angulatum*, when observed by very oblique light. This diatom mounted dry with the frustules adhering to the cover is seen in quite a new aspect; by causing the pencil of light to fall at right angles to the axis of the valve (or more generally parallel to any of the three ordinary lines). It then presents at the portion adhering to the thin glass cover white rectangular fields, separated by dark broad beams, alternating from row to row, paler lines crossing the white space between the black bands which are thus joined; the ratio of the length of the rectangular division comprised between the dark bands being to the width as $2 : \sqrt{3}$."

This unusual image results from the entrance into the field of a new set of diffraction images, or rather, of one (say *h*) of the twelve more distant diffraction images surrounding the six spectral images (*b*, *c*, *d*, *e*, *f*, *g*), which are always visible on Angulatum (with an objective of moderate aperture and central light), on removing the eye-piece and looking down the tube,* the dotted circle in the figure indicating the appearance of the field with central, as the darker ring does that of oblique light by which the more distant spectrum is admitted.



With light of the utmost obliquity on this diatom, a moderate angle admits only two (say *b*, *c*), or at most three, of the spectra of the first order, the more distant spectrum (say *h*), or at least its light-giving rays, being inaccessible.

This is the case also with the oil immersion lens on that part of the valve on which a film of air intervenes between it and the glass cover: under such circumstances the aperture is reduced to the maximum air-angle of 180° = 1 numerical aperture; hence, on the parts not in contact with the cover the ordinary hexagonal markings alone are usually seen, but with great brilliancy and distinctness, with either central or oblique light.

Further, Professor Abbe states that on *Frustulia Saxonica* the fine parallel longitudinal lines described by Mr. Hickie † are seen by

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* 'Monthly Micro. Journal,' vol. xvii. p. 82.

† Ibid., vol. xiv. pp. 32 and 274; vol. xv. p. 122.

using an illuminating pencil of extreme obliquity, incident at right angles to the axis of the valve, and a "perfect network," sharp and distinct, when the incident ray *from a paraffin lamp* is inclined at an angle of about 45° to the longitudinal and transverse striæ.

The more easy test of *Amphipleura pellucida* on Möller's Probe-Platte is readily seen, but as this diatom is in balsam an "immersion condenser" is of course necessary; that used by me is a non-achromatic triplet of 138° balsam angle = 1·40 of numerical aperture, made for me by Mr. Zeiss, under Professor Abbe's directions; but I find that another non-achromatic condenser of very large angle, which I have used for many years, is perfectly effective when similarly attached to the slide by a drop of water or oil.

The preceding observations, in which the expression "numerical aperture" has been more than once adopted, not unnaturally leads to some remarks on the more common measure of "*angular*" aperture.

It has long been evident that the time has arrived for a more rational definition of the resolving power of a microscope than that now in use. Even before the introduction of immersion objectives, the expression "angle of aperture" was deceptive as an indication of resolving power, inasmuch as resolving power is proportional to the *sine* of the *semi-angular aperture* of the objective, and not to the *angle* of aperture itself; and it is needless to dwell on the fact, that having regard to the small progressive increase in the sines of large angles, the ratio of resolving power can bear no proportion to the mere number of degrees.

But, since the invention of the immersion system, the present measure has become still more objectionable; it not only fails to give the relative resolving powers, but suggests apparent differences where there is no essential difference, and gives an appearance of identity where none exists.

In the last number of our 'Transactions,' a paper, by Mr. Zeiss, on Abbe's Apertometer, explains the meaning of the expression "numerical aperture."

Briefly stated, it is equal to *the product of the refractive index of the medium in front of the objective, multiplied into the sine of the semi-angular aperture* = n sin. w.

This definition of "numerical aperture" offers at once a means by which all objectives, whether dry, water, or oil immersion, can be directly compared. It is based on the theory whence Professors Abbe and Helmholtz deduced the limit of visibility.

The wave-lengths of the various coloured rays composing the diffraction spectrum being shortened on entering different media in front of the objectives, in the ratio of their respective indices of refraction, affords one of the most complete, as it is one of the most beautiful, explanations of the great resolving power of immersion lenses. The diffraction spectra arising from the structural peculiarities of the object, on the exact superposition of which the resolving power exclusively depends,* are by the retardation brought nearer to the illuminating pencil; the invisible portion of the spectrum becomes luminous, and the blue and violet assume the colours of the less refractive or light-giving rays, and thus the surrounding spectral images, being thus drawn together, or, if I may use the expression, are so shrunk in, as to be admitted into the *apparently* reduced aperture of the objective.

Thus the angle of the oil immersion lens which I have endeavoured to describe, being 113°, gives a semi-angular aperture of 56½°, of which the sine is 0·839, which, multiplied by 1·50, the refractive index of the oil, gives a "numerical aperture" of 1·25; hence we see that we have in it a resolving power exceeding the possible limit of a dry lens (sin. 90 = 1) by no less than 25 per cent.

This numerical aperture of 1·25 is, however, as I have said before, effective to the full extent only, on condition that the refractive index of the medium in which the object is mounted is not less than 1·25; but if a dry object adhere to, and is in physical contact with, the thin glass, the resolving power will be a mean between 1 and 1·25 = 1·125, i.e. a mean between the maximum resolving powers in air and in balsam.

Hence it will be seen that the resolving power of an immersion objective is greater on an object in balsam than in air, if its "numerical aperture" be > 1; provided always that the difference in the refractive indices of the object observed and the medium in which it is mounted is sufficiently great to render the diffraction images bright enough for observation.

In conclusion, I beg to tender my warmest thanks to Dr. Abbe for the prompt, efficient, and extremely kind manner in which he responded to my appeal, as by his ability alone my idea has been carried into effect, and the use of high powers rendered more facile and therefore, as I hope, more popular.

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* Dr. Abbe's article in Schultze's 'Archiv Mikroscopische Anatomie,' vol. ix.

V.—*The Structure of the Coloured Blood-corpuscles of Amphiuma tridactylum, the Frog, and Man.* By Dr. H. D. SCHMIDT, Pathologist of the Charity Hospital, New Orleans, La.

(*Taken as read before the* ROYAL MICROSCOPICAL SOCIETY, *April* 3, 1878.)

PLATE IV.

NOTWITHSTANDING the numerous investigations which have been made for the purpose of determining the true structure of the coloured blood-corpuscles, the views on this important subject, it appears, are still varying, leaving it an object for further research and discussion.

Formerly, these bodies were almost universally regarded as true cells, consisting of a cell-membrane, enclosing the protoplasm; and this view was entertained of the round bi-concave non-nucleated blood-disks of the blood of the Mammalia, as well as of those ellipsoidal nucleated bodies met with in the blood of other classes of vertebrated animals.

EXPLANATION OF PLATE IV.

In order to enable the reader to compare the relative sizes of the blood-corpuscles discussed in the paper, all figures, with the exception of 45, 46, and 47, have been represented enlarged by the same magnifying power, viz. 420 diameters.

FIG. 1.—Front view of a coloured blood-corpuscle of *Amphiuma tridactylum.*

FIG. 2.—Side view of the same.

FIGS. 3 to 12.—Various forms of coloured blood-corpuscles of the Amphiuma, produced by spontaneous contraction of the protoplasm.

FIG. 13.—Representation of a coloured blood-corpuscle of the Amphiuma, the membraneous layer of which has burst; *a*, colourless protoplasm exposed to view; *b*, membraneous layer (coloured).

FIG. 14.—Fragment of a coloured blood-corpuscle found in the fresh blood of the Amphiuma.

FIG. 15.—Coloured blood-corpuscle of the Amphiuma, enclosing minute crystals.

FIG. 16.—Another, enclosing vacuoles.

FIG. 17.—Another form of vacuoles.

FIGS. 18, 19, and 20.—Coloured blood-corpuscles of the Amphiuma, treated with water.

FIGS. 21 and 22.—The same, with their nuclei escaping through a rent in the membraneous layer.

FIG. 23.—Nuclei, escaped from the corpuscles, with their contents escaping through a small rent in their enveloping membrane; *a*, the contents escaping in the form of a small sphere; *b*, the same, after having been treated with a weak solution of chromic acid; *c*, the contents escaping in the form of a cone.

FIG. 24.—Singular appearance of a coloured blood-corpuscle, treated with water, and subsequently with a weak solution of chromic acid.

FIG. 25.—Coloured blood-corpuscle of Amphiuma, treated with chloroform vapour.

FIG. 26.—Coloured blood-corpuscle of Amphiuma, treated with chloroform liquid.

FIG. 27.—Coloured blood-corpuscle of Amphiuma, treated with diluted acetic acid.

A number of years ago, histologists began to deny the existence of an enveloping membrane in the coloured blood-corpuscles, and maintained that the latter consisted of protoplasm only, united with a colouring material, the *hæmoglobin.* In support of this view, they referred to the bi-concave form of the blood-corpuscles of the Mammalia, and also to the great elasticity which all blood-corpuscles show they possess in assuming almost any form to adapt themselves to the various curvatures and angles of the smallest capillary vessels through which they have to pass; properties which could not be possessed by a vesicular body. The behaviour of the blood-corpuscles towards various reagents, and finally, the impossibility of demonstrating this enveloping membrane, were also adduced to prove its absence.

But while these histologists, by denying the existence of an enveloping membrane, were endeavouring to make the structure of these blood-corpuscles appear of a more simple nature, others, especially in Germany, propounded theories, according to which the construction of these bodies appears quite complex.

In explanation of the various phenomena manifested by the coloured blood-corpuscles, several hypotheses regarding their structure were advanced from time to time. Thus Rollett, denying the existence of the membrane, looks upon them as mainly consisting of a certain stroma, to which they owe their peculiar mechanical properties.* This view is based upon the examination of the colourless remains of the blood-corpuscles of the guinea-pig, horse, and dog, which he deprived of their colouring matter by a peculiar freezing and thawing process. Kuehne, another opponent of the membrane, strongly endorses the view of Rollett.

Another well-known hypothesis, founded upon certain appearances observed on the blood-corpuscles of the Triton, after having been treated with a 2 per cent. solution of boracic acid, is that of Bruecke. According to it, the nucleated blood-corpuscle consists of two parts. The one of these, representing a *porous* body, of a motionless, very soft, colourless, and transparent substance; the other a living organism, the central portion of which forms the nucleus, filling up the pores of the former, and, with the exception of the colourless nucleus, containing the hæmoglobin. The colourless porous substance, Bruecke named *oikoid*, the other part *zooid.* By the contraction of the latter from the former, he tries to explain the occurrence of those appearances observed on the blood-corpuscles of some Amphibia, consisting in the entire or partial retraction of the coloured contents upon the nucleus, and assuming in the latter case the form of a star, as represented by Rollett, on p. 286 of Stricker's 'Handbuch der Lehre von den Geweben, &c.'

This hypothesis, fanciful as it is, does not explain the pheno-

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* Kuehne, 'Lehrbuch der Physiolog. Chemie,' p. 190.

menon mentioned, unless the supposed pores represent conical tubes radiating from the centre toward the periphery. But as these have never been seen, of whatever shape they might be, the hypothesis has no foundation of observed facts to rest upon. Nevertheless, it has been received as the true theory by a number of histologists. Even Stricker has adopted this theory with a slight modification.

Hensen,* in observing the above-mentioned phenomenon, explained it as caused by the protoplasm of the coloured blood-corpuscles, collected around the nucleus and upon the inner surface of the cell-membrane (which he presupposed to exist), and connected by delicate filaments, radiating from the nucleus to the membrane; the interspaces left between the filaments contain the coloured liquid contents of the cell.

A similar theory, regarding the structure of the coloured blood-corpuscles of the Frog, has been advanced quite recently by Kollmann.† He also presumes the existence of a stroma, formed by a dense network of delicate filaments, extending from the nucleus to the transparent, elastic, enveloping membrane; the interspaces left between the filaments he supposes to contain the hæmoglobin. The characteristic form of the blood-corpuscles he supposes to be only possible by a certain degree of tension in the albuminous filaments of the stroma. An excessive contraction of the filaments is counterbalanced by the hæmoglobin contained in the interspaces. The coloured blood-corpuscles of the Mammalia also, have, according to his view, such a stroma.

Laptschinsky,‡ judging from the effect of different reagents upon the coloured blood-corpuscles of Tritons and Man, supposes them also to consist of two different substances. The one of these, designated by him as the "rest of the blood-corpuscle," is soft and elastic, and assuming mostly a round form, possesses in general all the properties of the so-called "stroma" of these bodies. The second substance becomes under the microscope only visible when, by the effect of different reagents, it is made to swell or precipitate.

Still other hypotheses concerning the structure of the coloured blood-corpuscles and the phenomena which they manifest, have been advanced; but as this article is not intended to present the history of these bodies, I shall forbear mentioning them.

In the course of the numerous investigations into the nature of the coloured blood-corpuscles, especially of the larger ones, containing a nucleus, they have, of course, been treated in various ways—mechanically, chemically, and physically; and there re-

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* Stricker, 'Handbuch der Lehre von den Geweben,' p. 295.

† Virchow and Hirsch, 'Jahresbericht, &c.,' für das Jahr 1874, band i. p. 49.

‡ *Loc. cit.*, p. 49.

mains hardly a chemical reagent, liquid or gaseous, to the influence of which they have not been subjected. Heat, moisture, as well as electricity in its different forms, have been applied. The changes occurring in their substance by the action of all these reagents, have been closely watched, and many deductions relating to their structure have been made.

An enumeration of the most important of these experiments will be found in Rollett's article "On the Blood," in Stricker's 'Handbuch der Lehre von den Geweben, &c.,' as well as in other treatises on this subject. But it is certainly strange that while great importance has generally been attached to the various changes occurring in the form of the blood-corpuscles by the action of the particular reagent (which, after all, are only due to a contraction or coagulation of their protoplasm), the *double contour* of these bodies, the only proof of the presence of a membrane, whether preexistent or artificially produced, is scarcely mentioned, and appears to be generally overlooked or ignored.

In my treatise "On the Origin and Development of the Coloured Blood-corpuscles in Man," published in the February number, 1874, of the "Monthly Microscopical Journal," I made some casual remarks in reference to the fine double contour observed in the human coloured blood-corpuscles after being deprived of their colouring matter by the simple action of that most neutral agent, water. On these *stomata*, then, as Rollett would call the altered corpuscles in question, a delicate double contour is always detected by close inspection. In directing attention to this double contour, however, I do not presume that its presence indicates a pre-existing true cell-membrane. But, as I have remarked in the above-mentioned article, I do suppose that the coloured blood-corpuscle of Man at maturity undergoes a slight condensation on its surface in the form of a thin layer or pellicle, which, resisting the solvent power of water, finally appears in the form of a double contour. To these conclusions, E. Ray Lankester had also arrived, from a series of observations which he made on the coloured blood-corpuscles, with regard to the action of gases and vapours. The results of these observations were published in the October number, 1871, of the 'Quarterly Journal of Microscopical Science.' "The red blood-corpuscle of the vertebrata," he says in his summary, "is a viscid and at the same time elastic disc, oval or round in outline, its surface being differentiated somewhat from the underlying material, and forming a pellicle or membrane of great tenacity, not distinguishable with the highest powers (whilst the corpuscle is normal and living), and having no pronounced inner limitation."

Lankester, therefore, regards the coloured blood-corpuscle as a viscid and elastic disk, which of course implies that its substance is homogeneous or without structure; he further supposes its surface to be differentiated from the rest of the body, forming a pellicle or membrane, though of no pronounced inner limitation, and undistinguishable by the microscope. The latter is true with regard to the small, bi-concave blood-corpuscles of the Mammalia; in the large, oval, nucleated corpuscles of the Amphibia, however, the pellicle, as we shall see hereafter, may be readily demonstrated. In the fresh blood of this class of animals we frequently meet with specimens of blood-corpuscles, on which, by a contraction of the protoplasm representing the greater portion of the whole body, the pellicle in question appears separated from the latter, thus manifesting its existence. Lankester himself mentions this fact (p. 368), and gives a representation of the specimens in Fig. 2, *a.* With due deference to the hypothesis of Bruecke, however, he calls the contracted protoplasm enclosing the nucleus, the *zooid*, and the *separated enveloping* pellicle, or membrane, the *oikoid.* Now, as far as I am able to understand the hypothesis of Bruecke, this oikoid represents a *porous*, transparent body; and I can therefore not comprehend how Lankester can unite this idea of a porous substance, supposed to embrace the nucleus, and to determine the whole form of the blood-corpuscle, with that of his pellicle or membrane. The hypothesis of Bruecke, ingenious as it is, must eventually prove to be but an unsuccessful attempt to explain certain changes observed to occur in the form of the protoplasm of the coloured blood-corpuscle, which, after all, form the exceptions to the rule, and are such as may be readily explained without ascribing to this body a structure more complicated than can be demonstrated.

A different view from the above is that entertained by Jas. G. Richardson, of Philadelphia. He upholds the old theory, according to which the coloured blood-corpuscles of the Vertebrata are vesicles, each composed of a delicate, colourless, inelastic, porous, and perfectly flexible cell-wall, enclosing a coloured fluid, &c. To this conclusion Richardson arrived, not only by his numerous examinations of the blood-corpuscles of Man and other Mammalia, but also by the study of the corpuscles of the *Menobranchus,* which, with one exception, are the largest known. An interesting paper, containing these investigations, was republished in the July number, 1871, of the 'Monthly Microscopical Journal.' In it, he states that he twice succeeded in cutting a corpuscle in two with sharpened needles; and that, on penetrating the vesicle with the edge of the needle, its contents were instantly evacuated, and disappeared at once in the surrounding fluid, while the cell-wall immediately shrunk together, and became twisted upon itself and around the nucleus into a perfectly hyaline particle.

But while Richardson maintains the true cell nature of the coloured blood-corpuscle, and adduced a number of observed facts in its support, it is singular that he should have entirely overlooked the only unmistakable evidence of the existence of a cell-wall, namely, the double contour, which the coloured blood-corpuscle shows under the conditions above mentioned.

With the view of bringing the still-existing controversy regarding the structure of the coloured blood-corpuscles somewhat nearer to a close, I instituted, during the summer and autumn of 1873, a series of microscopical researches upon this subject. The special material used for this purpose were those giant blood-corpuscles of the *Amphiuma means*, or *tridactylum*,* as the animal is called by European writers, and also those of the Frog and of Man. The examinations on the latter I have only lately carefully repeated. The former attain the enormous size of from $\frac{70}{1000}$ to $\frac{80}{1000}$ mm. in length, and from $\frac{46}{1000}$ to $\frac{48}{1000}$ mm. in breadth; thus exceeding in magnitude very considerably even those of the *Proteus anguineus*.

Knowing that the blood-corpuscles of this animal had never been thoroughly investigated, I devoted a great deal of care on their examination. A considerable number of animals of all ages and sizes were used. While some of them scarcely measured from five to six inches in length, and served for the study of the development of their blood-corpuscles, others had attained a maximum length of three feet, and a thickness equalling that of the wrist of a large man. I was also favoured, by chance, in obtaining the eggs of the animal, enabling me to examine the blood of the embryo.

As regards the application of the vapours of certain reagents

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* The *Amphiuma tridactylum* at New Orleans, vulgarly called "congo-eel" or "congo-snake," belongs to the order *Urodela* of the Amphibia, and ought not to be confounded with the *conger-eel*, a true fish, found on the coasts of North America, Great Britain, and France. From what I know, I presume that the name *congo-eel* or *congo-snake*, applied by the people to this animal, has originally been derived from the *Congo negroes*, formerly imported into this country from the *Congo* region on the coast of Guinea in Africa. It is very likely that these negroes, like some of their descendants at the present day, as I have been told, were in the habit of using the Amphiuma for food, and thus engrafted their name upon it. Although the popular belief of the venomous bite of the animal is unfounded, it is nevertheless savage enough to bite eagerly at anything held before it. Its skin is very smooth and slippery, not allowing a firm hold upon it. For this reason, to obtain its blood for examination, I placed the animal in a sack of coarse material, in which its movements are limited. An assistant then takes a good hold of it, through the sack, directly behind its head, with one hand, and around the belly with the other; the tail is then pulled out from the open end of the sack, and after being wiped perfectly clean, the extreme point of it is clipped off with a pair of scissors, until a small drop of blood, escaping from the caudal artery, appears. This method of obtaining the fresh blood is the best of all I have tried, for in vigorous adult animals blood seldom appears from an incision into the skin, or even into the underlying muscles. It seems that in this animal the arterioles and venules possess uncommonly strong muscular coats, by the contraction of which a hemorrhage is prevented. An account of the descriptive anatomy of the *Amphiuma tridactylum*, only lately issued by Dr. C. H. Hoffmann, of Leyden, will be found in Dr. H. G. Broun's 'Klassen und Ordnungen des Thier-Reichs, &c.,' a work still in progress of publication.

to the blood-corpuscles, I had, for want of a gas chamber, to resort to a more primitive method, which, however, answered the purpose perfectly. It consisted in placing the slide holding the film of fresh blood directly over the open mouth of a bottle containing the reagent. After exposing it to the action of the latter, from one-half to three minutes, or even longer, it was removed, and quickly covered by a plate of thin glass. In examining a number of specimens, exposed in this manner to the vapour of the reagent for various lengths of time, I was enabled to observe the changes taking place gradually in the blood-corpuscles as well, I believe, as if the latter had been enclosed in the gas chamber. For, whether the film of blood be enclosed in the gas chamber, or laid over the open mouth of the bottle holding the reagent, the blood-corpuscles will in either case not be affected simultaneously, unless the film is very uniform in thickness; those nearest to the surface will, of course, be acted on first. But even under equal external conditions, some of the blood-corpuscles seem to be more sensitive to the action of a particular reagent than others. The cause of this phenomenon must be sought in the peculiar conditions of these bodies at the time, such as age, composition, &c.

The Coloured Blood-corpuscles of Amphiuma tridactylum.—These blood-corpuscles resemble in shape and other peculiarities those of the Frog and other Amphibia. Each of them represents an oval disk (Fig. 1), enclosing an oval nucleus. The diameter of the disk ranges in different specimens from $\frac{70}{1000}$ to $\frac{80}{1000}$ mm. in length, and from $\frac{46}{1000}$ to $\frac{48}{1000}$ mm. in width. The mean diameter of the nucleus is about $\frac{27}{1000}$ mm. in length, and $\frac{17}{1000}$ mm. in width. The profile of these blood-corpuscles represents a biconvex disk, the middle portion of which swells out in the form of an oval prominence. This prominence, which is formed by the nucleus and a portion of the body of the corpuscle covering it, measures about $\frac{13}{1000}$ mm. in thickness. The thickness of the blood-disk itself, beyond the area of the nucleus, is about $\frac{6}{1000}$ mm.; it gradually diminishes toward the margin of the disk, where it only amounts to $\frac{2}{1000}$ mm. There are no sharp angles presented in the outlines of the profile of these blood-corpuscles, as I have seen them sometimes erroneously represented in those of the Frog and Salamander, where the whole corpuscle resembles a sphere set in a disk with a thick round border. On the contrary, the prominence at the place corresponding to the periphery of the nucleus is lost upon the disk in the form of a graceful curve (Fig. 2). The very margin of the disk is rounded. The colour of the corpuscles is of a dirty yellow with a slightly greenish tint, and in the fresh, normal specimen uniform throughout; in the centre, over the nucleus, however, they appear colourless.

In getting the margin of these blood-corpuscles by an accurate adjustment at the proper focus, it will be observed to represent an even border, about $\frac{2}{1000}$ mm. in breadth, which is distinguished from the rest of the body by a *decidedly greenish* tint (Fig. 1). With an oblique illumination, the existence of this greenish border becomes still more evident, so that even an inner contour, in the form of a delicate *shady* line, may be recognized. It is true, this inner contour is not comparable to the inner contour of a distinct cell-wall; nevertheless, it is sufficiently distinct to indicate the presence of a thin layer at the surface of the blood-corpuscle, differing in some respects from the rest of the body—as, for instance, in the refraction of light. In the accompanying drawings, this greenish border of the corpuscle is, for the sake of distinction, represented clear, while the yellow portion of the body is shaded.

It will be obvious that this observation is an important one; indicating, as it does, the existence of a thin layer at the surface of the blood-corpuscles, differing, if not in chemical composition, at least in density from the substance of the disks.

This layer may have, as Lankester remarks, no pronounced inner limitation, and may not, in the true sense of the word, possess the character of an enveloping membrane; but under certain conditions its connection with the underlying material is lost, and it appears in the form of a true membrane, manifesting itself by a double contour. Such conditions are especially brought about by the influence of certain reagents, as we shall see hereafter. But the same phenomenon is now and then also observed in the corpuscles of blood just escaped from the vessels. Thus, it sometimes happens that we meet in perfectly fresh blood, which has been quickly removed from the vessels and transferred to a slightly warmed slide, with specimens of blood-corpuscles, in which the protoplasm of the body of the corpuscles has, by a spontaneous contraction, become separated to a limited extent from the overlying denser layer representing the surface; so that the latter manifests itself by a fine double contour. In these instances, with the exception of the small vacuum produced by the retraction of the protoplasm, the blood-corpuscle has lost nothing of its normal appearance; its main body retains its slightly dirty, greenish-yellow colour, while the superficial layer or stratum appears in the form of a slight greenish border, the continuity of which over the vacuum is manifested by a fine double contour.

The phenomenon just described, I have not only observed in the blood-corpuscles of the Amphiuma, but also in those of the Frog (Fig. 49). All further doubts regarding the existence of a distinct stratum, or membraneous layer on the surface of these blood-corpuscles, differing in density if not in composition from the rest of the body, ought to vanish in the face of such self-evident facts.

A very singular observation which I made while examining a specimen of fresh blood, related to a large fragment of a coloured blood-corpuscle of the Amphiuma, having the appearance as if it had been cut or torn from the rest of the corpuscle (Fig. 14). On this fragment the membraneous layer was seen projecting on the torn surface. As there was no sharp instrument, nor any force used in the manipulation of transferring the blood from the vessel to the slide, I am unable to account for the presence of this fragment, except in one way, which I shall state farther on. In the blood of the Tree-frog I have several times met with coloured blood-corpuscles, of which a portion was wanting, as though it had been separated by means of a sharp instrument (Fig. 56, *c*).

The most interesting and important phenomenon which I observed was a fresh blood-corpuscle of the Amphiuma, on which the membraneous layer had apparently burst and retracted, leaving a portion of the underlying material, the protoplasm, exposed. The latter appeared entirely colourless, while the rest, still covered by the membraneous layer, exhibited the normal yellow colour of the corpuscle. In referring to Fig. 13, representing this specimen, we observe at *a* the colourless, uncovered protoplasm, bordered by only a single contour; while the portions *b* are coloured, and show the same light-greenish border as the uninjured normal blood-corpuscles. A few longitudinal folds, produced by a lateral contraction of the corpuscle, will also be noticed. As to the cause, by which in this case the membraneous layer might have been torn and the underlying protoplasm exposed to view, nothing definite can be affirmed. I can only explain the rupture of the said layer by a spontaneous expansion in a longitudinal direction of the protoplasm within; and that such an expansion does take place sometimes, I have actually observed in one case, to be mentioned presently. After the rupture has occurred, we may presume that the exposed protoplasm will be dissolved in the liquor sanguinis, and that the remains of the blood-corpuscle, consisting of the two coloured portions, *b*, continue to circulate until their final disintegration. This supposition would at the same time explain the presence of those fragments of blood-corpuscles met with in the circulating blood, as mentioned before.

The observation of a rupture of the membraneous layer of the coloured blood-corpuscle of the Amphiuma cannot be looked upon as other than an important fact, from which some practical deductions may be drawn. In the first place, it corroborates the existence of a membraneous layer or stratum on the surface of the blood-corpuscle, which was already not only indicated by the decided greenish border it exhibits, but moreover actually demonstrated by the manifestation of the layer itself in those cases above described, where it had become separated from the underlying protoplasm by contraction of the latter.

In the second place, it bears upon the question, still undecided, concerning the relationship of the hæmoglobin to the protoplasm. According to the theories of those histologists who regard the coloured blood-corpuscle as consisting of two different substances, the true seat of the hæmoglobin would be in the interstices of the porous substance. By another theory, more plausible than the preceding, the existing relationship of the hæmoglobin to the protoplasm of the blood-corpuscle would be that of an intimate mixture, without any chemical combination. Now, in consideration of the phenomenon (Fig. 13) under discussion, two different views regarding the true seat of the hæmoglobin may be taken. That is, either *it is held by the protoplasm*, and in this case escaped from that portion of protoplasm denuded of its overlying membraneous layer (Fig. 13, *a*) into the surrounding liquor sanguinis; or, judging from the coloured portions (*b*), *it is situated in the form of a thin stratum between the membraneous layer and the main body of the protoplasm*. If the latter should prove to be true, it would be, anatomically as well as physiologically, an interesting discovery.

When a minute portion of the blood of the Amphiuma is quickly transferred from the blood-vessels to the glass slide, and examined under the microscope, the coloured blood-corpuscles, with a few exceptions, present a normal appearance, such as before described. In almost all of them the nucleus can be well discerned, though its contours appear frequently somewhat indistinct. In some cases it appears quite distinct, while in others it is more or less hidden from view. The cause of this is its position, according as it happens to lie farther from or nearer to that surface of the blood-corpuscle which is towards the eye of the observer.

The nucleus represents a vesicle containing a number of large granules of irregular shape and size; its vesicular nature is indicated by a double contour, which, like the granules, is distinguished by a feeble greenish tint, while the rest of the nucleus is perfectly colourless.

Soon after the blood has been transferred from the vessels to the slide, certain changes of form are observed gradually to take place in a number of blood-corpuscles. These changes of form (Figs. 3 to 12), often very grotesque, are caused by a contraction of the protoplasm. They are usually preceded by a disturbance observed in the uniformity of the colour of the blood-corpuscle, announcing itself by some portions of the corpuscle appearing darker or more shaded than the rest. In some instances, however, the changes remain confined to the form, as in the Figures 3, 4, 7, 8, and 9, without any disturbance in the uniformity of colour. But in those cases where the blood-corpuscle by an energetic contraction of its protoplasm is thrown into wrinkles, as in the Figures 5, 6, 10, 11, and 12, the uniformity of colour is always disturbed by the irregular manner in which the contraction takes place. For while in some instances, as in Figs. 3, 4, &c., the contractive force seems to extend throughout the whole body of the blood-corpuscle either in one or the other direction, in others it appears in different points, affecting only separate portions of the protoplasm. Thus, wrinkles or folds extending in various directions will be produced. Sometimes they appear in the form of pointed projections, as processes and spines (Fig. 5); at other times the blood-corpuscle becomes constricted at one place, and assumes the form of a dumb-bell (Figs. 11 and 12).

Now, although these contractions of the protoplasm inducing those manifold changes in the form of the blood-corpuscles occur under the eye of the observer, they nevertheless become imperceptible, like the movements of the hands of a watch, by the gradual and irregular manner in which they take place. In one instance (Fig. 11), however, I observed very distinctly the spontaneous motion. This consisted in an expansion of the larger portion of the constricted blood-corpuscle (Fig. 11, *a*) assuming the form as represented by the outlines *b*, and finally recontracting to its former form *a*. This is the only case of spontaneous motion which I ever witnessed in the coloured blood-corpuscles of the Amphibia. In those of Man I have observed it in a number of instances, to be mentioned hereafter.

When water is applied to the specimen of blood under examination, the wrinkles and constrictions of those blood-corpuscles which were deformed in various ways by the contraction of their protoplasm, gradually disappear, and the corpuscles will be seen expanding, in order to resume their original oval form. At the same time, however, they are deprived of their colouring matter, and rendered colourless by the endosmotic current of the water into their interior.

Besides the phenomena exhibited by the fresh blood-corpuscles of the Amphiuma, described above, there are others which, though they have been previously observed on the blood-corpuscles of other animals, are still interesting enough to be stated in this place. They consist in the presence of crystals, and also of vacuoles or bubbles of gases in the interior of the corpuscles. As regards the crystals, besides Richardson having observed and described them as occurring in the blood-corpuscles of the Menobranchus, I have myself at different times met with them in the coloured corpuscles of the human embryo. In the latter instance, however, they may have formed after death, and by the action of a weak solution of chromic acid in which the specimen had been laid; in Richardson's case I am unable to state whether the blood was taken from the living or dead animal. In the *Amphiuma*, crystals are met with quite frequently in the interior of the coloured corpuscles of blood taken directly from the living animal. They represent minute *colourless* rods of $\frac{1}{1000}$ to $\frac{2}{1000}$ mm. in thickness, and from $\frac{5}{1000}$ to $\frac{15}{1000}$ mm. in length; they are slightly indentated, giving them the appearance of being composed of a number of segments (Fig. 15). In fact, they so closely resemble *Bacteria*, that when I first saw them I was impressed with the idea that they were dead specimens of these ambiguous beings. But I soon became convinced of their crystalline nature, by discovering that they dissolved when a drop of water was added to the preparation.

Not unfrequently blood-corpuscles are met with in the fresh blood, containing a considerable number of larger or smaller vacuoles in their interior. They resemble ordinary air-bubbles, being distinguished by a dark contour, which is gradually lost in a slight shade and a perfectly clear centre, and exhibits a light greyish tint, playing into violet (Fig. 16). In some cases the peripheral portion of these vacuoles is light, and of a pinkish tint, though with a dark contour, while their central portion is slightly shaded (Fig. 17). I have no idea of the exact nature of these bodies. As I found them especially numerous in the blood-corpuscles of an Amphiuma, which I had left three months without food, I am inclined to think that their formation is owing to some decomposition of the protoplasm. They invariably disappear on the application of water.

Having thus far described the coloured blood-corpuscles of the Amphiuma as they are met with in the fresh blood, together with the different phenomena which they exhibit in this condition, we will turn our attention to their behaviour when acted on by different reagents, and begin with the most neutral of these, namely, *water*.

When water is added to a specimen of fresh blood, the coloured blood-corpuscles will be observed to become gradually paler, until finally they are rendered perfectly colourless. This change, of course, is caused by the endosmotic current of the water penetrating into the blood-corpuscle and dissolving its colouring matter, which in consequence escapes into the surrounding liquid. During this process the blood-corpuscles do not swell; on the contrary, many of them become actually smaller by the continued action of water. A number of them assume a round form, which however, is not permanent, for the greater part of them eventually resume their original oval form, or very nearly so.

While the main body of the blood-corpuscle is rendered colourless by the action of the water, certain changes are observed to take place in its nucleus. The granules contained in the interior of this body are dissolved, and, after first expanding, run into each other, representing a homogeneous mass of a pale greenish tint. At the same time the whole body of the nucleus, now distinguished by a delicate but distinct double contour, expands, and in most cases assumes a more round, sometimes even irregular form (Figs. 18 to 23).

By a continued action of the water, the contour of the blood-corpuscles is rendered still paler, until they finally become almost invisible to a careless observer. By a closer examination with a *first-class* objective, however, their outlines are readily distinguished in the form of a very delicate *double contour.* This examination is facilitated by the presence of the nuclei, around which the observer has to look for the contour of the main body of the corpuscle.

It has already been mentioned that the coloured blood-corpuscles of the Amphiuma do not enlarge under the action of water, but, on the contrary, appear smaller in the dimensions of their front view. This diminution of size may be due to a partial or entire dissolution of their protoplasm by the water, and a simultaneous contraction of the outer membraneous layer, manifesting itself by the delicate double contour. That this layer really does contract will be further demonstrated hereafter. But the diminution of the corpuscle in length and breadth may be also due to an increase in its thickness, caused by the swelling and consequent roundness of the nucleus. In a number of cases the outlines appear wrinkled (Fig. 19), the cause of which may be sought in a momentary over-distension of the membraneous layer by the endosmotic current of the water, and a simultaneous expansion of the protoplasm preceding the contraction of this layer. Quite frequently the nucleus is displaced from its original seat, the centre of the blood-corpuscle, and is seen moving about in the interior of the latter. This phenomenon is readily explained. In the normal condition the density of the protoplasm is such as to hold the nucleus in the centre; but as soon as the water enters, it becomes lowered by the solvent action of this fluid, and in consequence the nucleus is set in motion by the force of the endosmotic current. In a number of cases, however, the phenomenon is not confined to a mere displacement of the nucleus, but enters into another phase by the entire escape of this body through a small rupture of the membraneous layer (Figs. 21 and 22). Such an escape of the nucleus does not take place very rapidly, as might be thought; but in most cases is a slow process, offering ample time for observation. From this fact we may conclude that the orifice produced by the rupture in the membraneous layer is at first scarcely large enough to allow the nucleus to drop out; but that it is rather gradually enlarged by this body being pressed through it by some propelling force from behind. The whole phenomenon may be explained as follows: When the water enters into the interior of the blood-corpuscle, it is taken up by the protoplasm, and its first effect is a swelling or expansion of this substance, accompanied by a corresponding distension of the membraneous layer, causing in many cases a rupture as above stated. At this time the density of the protoplasm is still sufficiently high for keeping the nucleus in its normal place, the centre. But by the continued action of the water upon the protoplasm, the density of the latter gradually diminishes until, in virtue of the law of diffusion, it is rendered equal with that of the surrounding fluid. As soon as the rupture occurs, therefore, the distended membraneous layer, being now relieved from its pressure by an escape of a portion of the fluid within and through the orifice produced by the rupture, commences to contract. Now it is that the nucleus is seen to leave the centre and to approach the inner surface of the membraneous layer. Finally, by the continued contraction of this layer it arrives at the orifice, through which it is slowly pressed. It is owing to this process that a considerable number of free nuclei are always met with when the blood of the Amphibia is treated with the water. And as no contour of the main body of the blood-corpuscle can be discovered around them, it might appear as if the whole, except the nucleus, had been dissolved by the reagent.

In accepting the view of those histologists who deny the existence of an enveloping membrane of the nucleated coloured blood-corpuscle, and supposing it to consist only of a homogeneous protoplasm throughout surrounding the nucleus, it becomes difficult to explain in a satisfactory manner the phenomenon just described. Rollett, in his article "On the Blood," in Stricker's 'Handbuch der Lehre von den Geweben, &c.,' also mentions the above-described phenomenon observed on the nucleated blood-corpuscles, but omits to offer any explanation. And indeed, maintaining, as he does, the idea that the body of the blood-corpuscle consists of a certain stroma determining its form, and insoluble in water, I cannot conceive of any rational explanation which he could offer. As the nucleus occupies the centre of the stroma, it of course cannot become displaced as long as the consistence of the stroma remains unaffected by the water, unless the stroma itself is torn or loses its integrity in some way or other in that direction in which the nucleus moves. But then the question remains to be answered: What is the force that displaces the nucleus? Is it a spontaneous contraction of the stroma? If so, the nucleus would only be embraced the firmer, unless a rupture of the stroma occurs, allowing it to escape. But it does not always escape, as Rollett states himself; it is only displaced from the centre to an excentric position. Therefore, admitting even that the nucleus is able to assume an excentric position when surrounded by a homogeneous substance of a certain consistence, as this stroma must certainly be in order to preserve the form of the blood-corpuscle, the question remains to be answered: What is the resisting force at the periphery which prevents it from escaping altogether if there exists no outer layer more consistent than the stroma itself? Sometimes the nucleus is observed to change its place suddenly by a certain start or jerk, while at the same time the whole blood-corpuscle rebounds to a little distance. This is another phenomenon difficult to explain upon the stroma theory, but easily accounted for in viewing the structure of the blood-corpuscle, such as I have described it above. The sudden displacement of the nucleus is caused by the contraction of the membraneous layer, over-distended by the expansion of the protoplasm, and occurs just at the time when the density of this substance has been rendered sufficiently low by the action of the water to allow the nucleus to move in it, and to leave its central position. In order to make the blood-corpuscle rebound, however, the weight of the nucleus must be greater than that of the rest of the corpuscles; and, besides, the contraction of the membraneous layer must take place unequally.

Another phenomenon exhibited by the nucleated ellipsoidal blood-corpuscles of the Amphibia is that of assuming a round form, when treated in water; it also has frequently been discussed and adduced for the purpose of either proving or disproving the existence of an enveloping membrane. Now in both cases it will be difficult to find a satisfactory explanation as long as we only keep in view the change of form which takes place in the main body of the blood-corpuscle. It seems to me more probable that the phenomenon originally depends on the dissolution of the granules in the interior of the nucleus; causing this body to swell and expand, and in consequence to assume a round form, which finally determines temporarily the form of the whole corpuscle. In accepting this explanation, however, the change of form in the nucleus itself, still remains to be accounted for.

An interesting observation regarding the nucleus itself remains still to be mentioned. In a number of cases, during or after the escape of the nucleus, its delicate enveloping membrane, indicated by the fine double contour, bursts also, allowing the contents to exude. They generally escape in the form of a small spherical body (Fig. 23, *a*), which gradually enlarges as the process is proceeding. Sometimes the escaping contents assume a more conical form, as represented at *c*. They are very pale, and bordered only by a delicate single contour. With the application of a very weak solution of chromic acid, this single contour becomes double, and is rendered much more distinct (Fig. 23, *b*). At the same time the double contour of the nucleus appears darker, and the contents within become finely granular. This change, of course, is caused by the action of the chromic acid, coagulating the surface of the escaping contents in the form of an artificial enveloping membrane, and rendering the remaining contents in the interior of the nucleus granular; while the darkness of the double contour of the nucleus itself is caused by an increase in density of the wall, which it represents.

When the coloured blood-corpuscles of the Amphiuma are treated with a weak solution of chromic acid, and the action of the reagent continues, they are rendered colourless. At the same time, they are bordered by a distinct double contour, and their protoplasm appears finely granular. The nucleus also is distinguished by a dark double contour and by granular contents. Finally, if the action still continues, the granular contents of the corpuscle are dissolved, and the latter appears as a clear cell with a double contour.

Concerning the action of a weak solution of chromic acid upon these blood-corpuscles, I have made an interesting observation. When a fresh specimen of the blood of Amphiuma is treated with water under the microscope, and subsequently, after the coloured blood-corpuscles have become discoloured and rendered very pale by the action of the water, and a very weak solution of chromic acid is added, the following changes will be observed to take place in a number of the corpuscles: becoming almost invisible, they will reappear, bordered by decided dark double contours, while their nuclei, also distinguished by dark double contours and granular contents, are coloured yellow from the reagent. But the most interesting part of the phenomenon is a series of fine lines, radiating from the periphery of the nucleus through the protoplasm to the inner surface of the membraneous layer of the blood-corpuscle (Fig. 24). Now this picture would almost seem to corroborate the theory of Hensen, as well as that of Kollmann; the fine double lines representing the filaments, which they suppose to radiate from the nucleus to the enveloping membrane. But this is not the case. For a closer examination reveals that these lines represent nothing but fissures in the protoplasm, which appears to have assumed some form of crystallization. This becomes more evident by observing some of these fissures, deviating from their course and giving rise to subordinate branches, as is seen in Fig. 24.

What this colourless crystallizable constituent of the protoplasm, manifesting itself by the above-described reaction with a weak solution of chromic acid, may be, I must leave to the organic chemist to decide. It will be remembered, however, that a number of years ago Lehmann succeeded in discolouring the original blood-crystals, demonstrating the albuminous body in its crystalline form,* though Kuehne, who regards the coloured blood-corpuscles as consisting of a certain stroma, in the interstices of which the hæmoglobin was to be contained, subsequently declared this

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* O. Funke, 'Lehrbuch der Physiologie,' 4th edit., vol. i. p. 40.

observation to be erroneous.* If the latter investigator is right, of what do those minute *colourless* crystals, observed in the fresh coloured blood-corpuscle of the Amphiuma, consist?

It remains to be mentioned that I have not invariably succeeded in producing the phenomenon in question in these blood-corpuscles. The failure, I suppose, was occasioned by not having applied the reagent soon enough, or else too late, as respected the action of the water upon the blood-corpuscles; or perhaps the strength of the solution, to ascertain which I took no care, may have been the cause. In some cases the corpuscles appear dotted over with minute granules; these belong to the liquor sanguinis surrounding them, and are produced by the action of the chromic acid.

When the blood-corpuscles of the Amphiuma are exposed to the action of chloroform vapour, they become entirely discoloured in about two minutes. When exposed somewhat longer, their outlines become very faint, but may always be discovered in the form of a double contour by close examination with a first-class objective; frequently they are hidden by the colouring matter escaped from the corpuscles into the liquor sanguinis. The nucleus is not affected by the vapour of the chloroform; on the contrary, it is rendered more distinct (Fig. 25).

In exposing the blood-corpuscles to the action of water, after they have been discoloured by the vapour of chloroform, almost the same changes will be observed as when treated with water in their fresh condition. They then appear clear, bordered by a faint double contour; they do not swell, but rather appear to diminish in size, owing to the escape of their contents by the action of this fluid. The nucleus, however, is seen to swell very considerably; in some cases to such an extent as nearly to fill the interior of the corpuscle. At the same time, by the dissolution of its granules, its contents appear homogeneous and very pale. If at this stage the preparation is subjected to the action of a weak solution of chromic acid, the outlines of the blood-corpuscles will appear more distinct, but not as dark as when in their fresh condition and when they are only acted on by water.

When a fresh specimen of blood is treated with chloroform liquid, the blood-corpuscles, besides being rendered colourless, as in the previous case, become considerably reduced in size; their diameter scarcely exceeding $\frac{45}{1000}$ mm. in length, and $\frac{25}{1000}$ mm. in breadth. Being bordered by distinct, though pale double contours, they contain numerous well-defined minute granules; their form is now more or less oval or even irregular. Their nuclei also are distinguished by very distinct dark double contours, and contain a number of larger and smaller pale granules (Fig. 26), while their

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* Kuehne, 'Lehrbuch der Physiologischen Chemie,' p. 207.

form is round or slightly oval. Being subsequently treated with water, the same changes are observed to take place on the blood-corpuscles as when treated by this liquid in their fresh condition; that is, the minute granules in their interior are dissolved and the corpuscles appear clear with pale contours. The nucleus is seen to swell, while the large granules it contains are dissolved, giving to the whole a pale homogeneous appearance. In a number of cases also, the delicate membraneous layer of the corpuscles bursts, allowing the nucleus to escape as before described. If now, after the blood-corpuscles have passed through these various changes, produced by the chloroform liquid and the water, they are finally treated with a weak solution of chromic acid, nearly the same changes will be witnessed as are produced by this reagent on the fresh blood-corpuscle, namely, the size of the corpuscle becomes still more reduced, the faint delicate double contour, together with that of the nucleus, appears darker and more distinct, and the contents of the nucleus are rendered finely granular; in some cases even, its original larger granules are observed to reappear.

Diluted acetic acid discolours the blood-corpuscles and causes them to swell. Their outlines are then represented by pale greenish, delicate double contours, and in their interior numerous granules of the same tint are observed, which disappear by the continued action of the acid, or when applied in a stronger form. Eventually the membraneous layer, distended by the reagent, contracts again, and the blood-corpuscle reassumes its original form, or, as observed in a number of cases, its outlines appear wrinkled or otherwise irregular. Frequently the nucleus leaves its central position, and floats about in the interior of the corpuscle, or may escape through a rupture of the membraneous layer. The granules within the nucleus are observed to swell; but while some coalesce and fuse to a certain extent with each other, assuming a worm-like or varicose form, others preserve their original shape and individuality. The double contour of the nucleus disappears, and a dark single contour takes its place, which appears as if belonging to the fused granules; for those not fused are bordered by one of the same character. Around this dark contour a slightly reddish zone in the form of a border is observed, which I suppose to represent the wall of the nucleus, altered by the reagent (Fig. 27). The granules of the nucleus, after having been once exposed to the action of the acetic acid, seem to resist the solvent action of water.

When the coloured blood-corpuscles of the Amphiuma are exposed to the action of a 2 per cent. solution of boracic acid, they are gradually rendered colourless. The double contour, which appears very distinct, is of a greenish tint. The nucleus also is very pale, but shows distinctly its granules and double contour.

On many of the blood-corpuscles a number of straight longitudinal folds are observed. These disappear again by the continued action of the acid vapour, and the wrinkled surface of the corpuscle then appears as smooth as before. But in the depth of some of the previously existing folds a fine stripe of a pink colour is left, appearing to represent a rent or fissure in the contents of the corpuscle.

When the 2 per cent. solution of boracic acid itself is applied to the blood-corpuscles, they are rendered pale, and their contents appear finely granular, while the double contour becomes very distinct. Finally, by the continued action of the acid the granular appearance is lost, and they become perfectly clear. The nucleus is rendered coarsely granular, and its outlines appear irregular and serpentine; the outer contour of its enveloping membrane is dark, while the inner one has become more indistinct (Fig. 28).

Exposed to the action of the vapour of a 4 per cent. solution of osmic acid for about five minutes, the blood-corpuscles are rendered paler, almost colourless. Their double contour appears somewhat more distinct than in their fresh condition. The nucleus remains almost unchanged. In some cases its outline and granules become more distinct. But while perhaps the greater portion of the blood-corpuscles remain unaltered in form, a number of smooth wrinkles running mostly in a longitudinal direction are observed on others. Some of these latter have assumed a dish-like form, the nucleus projecting on the convex surface (Fig. 29).

In exposing the coloured blood-corpuscles to the vapour of a solution of osmic acid of only 2 per cent. for about two or three minutes, the above-mentioned changes do not occur, but the corpuscles remain almost entirely unaltered in appearance. For this reason E. Ray Lankester, in his article " On the Red Blood-corpuscle " mentioned in the beginning of this paper, recommended the vapour of a solution of osmic acid as the best agent for the preservation of these bodies. I can endorse his recommendation; for a number of specimens of the blood of the Amphiuma and the Frog, prepared in this manner and mounted in glycerine instead of in a nearly saturated solution of acetate of potassa more than three years ago, show hardly any alteration up to this time. Previously to employing the glycerine, I had made use of the solution of acetate of potassa, but found it rendered the blood-corpuscles very indistinct in quite a short time.

In exposing a specimen of blood of the Amphiuma to the action of the vapour of a 50 per cent. solution of the hydrate of chloral for about two minutes, a portion of the coloured corpuscles are rendered paler without alteration of their form, while others are wrinkled in a longitudinal direction. In a third portion, however, the protoplasm is observed to contract in the form of an irregular mass upon the nucleus, which becomes hidden from view. The rest of the body, after having considerably contracted and assumed an irregular angular form, breaks up into small fragments. After an exposure of about ten minutes, the blood-corpuscles become entirely discoloured, the nucleus before hidden reappears, showing a distinct irregular serpentine double contour, and also the granules in its interior.

The changes taking place in these blood-corpuscles when treated with the solution of the hydrate of chloral are very interesting and important, as they manifestly show the existence of the membraneous layer of these bodies, such as I have described it. Thus, after the solution has been applied, the protoplasm of the blood-corpuscle without much or any alteration of form gradually contracts upon the nucleus. As the result of this contraction, *it becomes entirely separated from the membraneous layer, which manifests itself in the form of a delicate double contour* (Figs. 30, 31, and 32). The interspace left between the contracted protoplasm and the double contour representing the membraneous layer is very considerable, as will be seen from the drawings, and it seems to me should be sufficient evidence to prove the existence of such a layer to an unbiassed mind.

At first the protoplasm is observed to become coarsely granular. When its contraction and simultaneous separation from the membraneous layer commences, it assumes a fibrillar appearance at its periphery (Fig. 32), and as the metamorphosis proceeds similar fibrillar rings concentrically arranged appear throughout the whole mass (Fig. 30). A number of coarse granules are observed to adhere to the contracted mass or to its periphery. In fact, it appears almost as if those concentrically arranged fibrillæ were produced by a fusion of granules. The contracted protoplasm retains its yellow colour, while the membraneous layer and also the vacuum left between it and the former are perfectly clear. Although the general oval form of the blood-corpuscle, especially of its membraneous layer, remains unaltered during the whole process of metamorphosis, its size is very considerably reduced; for in many instances its long diameter amounts only to $\frac{50}{1000}$ mm. in length, or seven less. Considering this great diminution in the size of the blood-corpuscle, it seems that when the protoplasm commences to contract the membraneous layer contracts simultaneously to a certain limit, beyond which it cannot contract any farther; if then the contraction of the protoplasm continues, a separation from the membraneous layer must be the result. The nucleus undergoes almost no change by the action of this solution; it is only rendered more distinct.

When the action of the solution of the hydrate of chloral is allowed to continue for some time, the contracted protoplasm is perfectly discoloured, and finally dissolved. During this process it happens that in some instances another delicate double contour is observed inside of that representing the membraneous layer (Fig. 33). This phenomenon may be explained by supposing the surface of the contracted protoplasm to have been rendered more dense by the action of the hydrate of chloral than the rest of the mass, in consequence of which it may resist longer the continued and subsequent solvent action of the reagent, and manifests itself like the membraneous layer of the blood-corpuscle in the form of a double contour. But it also disappears finally by the continued action of the reagent, and nothing but the original double contour representing the membraneous layer is left.

Exposing the blood-corpuscles of the Amphiuma to the action of nitric acid vapour for about two minutes, the following changes are observed to take place. At first, while retaining their colour, they are rendered very distinctly granular. Gradually becoming paler, they are finally entirely discoloured, retaining a delicate finely-granular appearance with a distinct double contour of a greenish tint (Fig. 34). They retain their natural size, and most of them also their oval form. None of them are observed with folds; and as blood-corpuscles with some folds or wrinkles are met with in most specimens of fresh blood, it may be supposed that this reagent renders them smooth again. The nucleus is coarsely granular, almost natural, though more distinct.

In applying the nitric acid liquid to a specimen of fresh blood, the changes taking place in the structure of the blood-corpuscles are very striking. The granules in the interior of the nucleus become dissolved, causing this body to swell and appear cloudy, while its wall is rendered very distinct. The protoplasm appears in the form of a network, with larger and smaller round, oval, or angular meshes, which in some cases are arranged in a radiating form; the largest at the inner surface of the membraneous layer, the smaller ones near the nucleus (Fig. 35). The double contour, representing the membraneous layer, remains distinct from the coagulated protoplasm, and in many corpuscles an interspace occupied as it seems by some fatty material exists between these two parts, or between the protoplasm and the nucleus. The form of the greater part of the blood-corpuscles has become irregular, and their size reduced.

Nitric acid diluted with equal parts of water produces almost the same changes in the blood-corpuscles as when applied pure. The granules within the nucleus are not always found dissolved, nor are the interspaces between the protoplasm and the membraneous layer or the nucleus met with so frequently (Figs. 36 and 37).

Ether causes the colouring matter of the blood-corpuscles to escape into the liquor sanguinis until they become perfectly pale, while the nucleus is rendered more distinct. The double contour of the corpuscle appears faint, though distinct. In many instances the contour appears wavy, indicating a contraction of the membraneous layer (Fig. 38). The colouring matter escaped into the liquor sanguinis also disappears finally, while the latter is rendered granular by the action of the ether.

(*To be continued.*)

NOTES AND MEMORANDA.*

Diatoms in Coloured Liquids.—Dr. Hamilton L. Smith (U.S.) writes to the Belgian Microscopical Society:—"The communication which exists between the internal protoplasmic substance and the exterior does not take place along the sutures of the connectives, but in *Navicula* (properly so called) it exists along the raphé or median line of the valves, and in *Surirella* and *Nitzschia* along the edges of the wings or of the carinæ.

"I possess some drawings showing the injection of indigo along *the median line* and its penetration into the interior of the diatom, especially in *Stauroneis* which had lain some days in water saturated with indigo. Apart from this demonstration, I have been able to obtain, by employing this pigment, an idea of the mode of progression of some large species of *Pinnularia.*

"On observing a living *Pinnularia* under the microscope, when the field has been made blue with indigo, and the object is looked at on the valvate side (that is to say, with the median line turned towards the eye), small particles of indigo are seen to run all along this median line and to accumulate near the centre in the form of a small ball or sphere. Looked at from the side of the connective (front view), a ball is seen to form in the centre of each valve; and what is remarkable, each of these small spheres turns on its axis with a *tourbillon* motion, just as would be the case if a small jet of water issued beneath it from a small orifice situated at the central point of the median line.

"When the balls have attained a certain volume they suddenly burst, and the particles of indigo then proceed with a retrograde motion along the frustule. Immediately after the rupture of the ball, a new one begins to form in the same place. The particles take a given direction, whilst the diatom itself follows the contrary direction. If the motion of the diatom is reversed, the particles of indigo follow an opposite course to that indicated. I have observed this curious phenomenon for hours together, and it was a glorious spectacle. I had in the field of the microscope some magnificent specimens of large *Pinnularia*, and the phenomenon showed itself specially distinct, when in consequence of a grain of sand or other obstacle the free motion of the frustule was arrested. The colour I used was the ordinary blue indigo water-colour paint, applied in a pretty concentrated form.

"Another observation which I made at that time proved to me the existence of a gelatinous external hyaline envelope to the frustule, which prevented the direct contact of the particles of indigo with the siliceous

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* It is intended that each number of the Journal shall in future contain notes of the articles in foreign journals which relate to the microscope or the various subjects of microscopical research. Also notes of new books or new editions and of the contents of the English and foreign microscopical and other journals which can be referred to in the Society's library. The Journal will thus contain a record of the progress of microscopy both in England and abroad, and the Fellows will be able to ascertain from time to time what has been published of interest to them in the various periodicals.

part. When the diatom moved it pushed before it a cordon of particles of indigo, which kept always at the same distance from the anterior portion of the frustule, and which were repelled during the movement of the diatom. A very slight application of red aniline (Fuchsine) demonstrated conclusively the existence of the gelatinous envelope ordinarily invisible; for it colours it distinctly even before the tint has made its appearance in the field of the microscope. Aniline always instantly stops the motion of diatoms with which it comes in contact."

Abnormal Appearances of Hydra viridis.—Mr. Sydney J. Hickson, while examining specimens of this polyp in Professor Lankester's class, University College, noticed one which exhibited twelve or fourteen sperm sacs, although it was budding at the same time. The young budded hydra had one tentacle, with a short oval outgrowth at the tip, giving it a forked appearance, and below the normal row of tentacles was a second row. The parent polyp exhibited a constriction a little way below the tentacular row, and from the constricted part sprang three tentacles, forming an incomplete second row. These three tentacles were more sluggish in motion than the others. In the course of a week the bifid tentacle disappeared, one half having probably dropt off; the sperm sacs increased in size and some burst, and a definite constriction appeared towards the basal end, as if fission were commencing. An unfortunate accident prevented further observations. Mr. Hickson observes that Johnston cites the following passage from 'Baker on the Microscope':—"Instead of buds of little protuberances, the body sometimes pushes forth single tentacula scattered irregularly over it, and these can be metamorphosed into perfect polypes, the base swelling out to become the body, which again shoots out additional tentacles to the requisite number."

Rhizopods in an Apple-tree.—Professor Leidy mentions that while waiting at Swarthmore for the train to return home, his attention was attracted to a large apple-tree which shortly before had been prostrated by a storm. In the fork of the trunk there was a bunch of moss which he collected and took home. On washing the moss and examining the water, he was not a little surprised to find in it many rhizopods. Of these, one was *Difflugia cassis*, and was abundant. Another was *Difflugia globularis*, few in number. The others were *Trinema acinus*, *Euglypha alveolata*, and *Euglypha brunnea*. The position of these animals, in the moss on the tree, was about eight feet from the ground.*

On an Ostracode Crustacean of a new Genus (Acanthopus), met with in the deep Waters of the Lake of Geneva. By M. H. Vernet.—This entomostracan cannot be referred to any type hitherto observed in fresh water; it belongs to the marine family Cytheridæ. Like the representatives of that family, it possesses only a single pair of maxillæ, and, on the other hand, three pairs of feet armed with strong hooks at their basal articulation (the other fresh-water Ostracodes having two pairs of maxillæ and two pairs of legs). The rudimen-

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* 'Proceedings of the Academy of Natural Sciences of Philadelphia,' Dec. 18, 1877.

tary post-abdomen is reduced to two rounded lobes, each bearing two hairs. The antennæ also much more resemble the type of the Cytheridæ than that of Cypridæ.

The reproductive apparatus does not present anything peculiar; it resembles that of the Ostracodes in general. Besides the sexual tube there is a *receptaculum seminis* in the female, and a very complicated chitinous copulatory apparatus in the male. The vulvæ are placed below the two post-abdominal lobes.

With regard to its mode of life, this crustacean is unable to leave the bottom. It does not swim at all; it sometimes creeps, but usually buries itself, and thus travels in the mud and organic débris by the aid of its feet and antennæ. The hairs and segments of the feet are driven into the mud, which serves as a support. The strong hooks of the basal articulation are especially useful, but give a somewhat awkward appearance to the mode of progression. The mechanism of this locomotion may be compared to that of a man who endeavours to advance upon his knees, aiding himself with his toes.

The two pairs of antennæ act in opposite directions; their action may be compared to that of the two anterior paws of a mole. These are the members which enable our crustacean to bury itself in the mud.

With reference to the origin of this organism two suppositions may be formed: it may be descended from a marine species introduced by some means into our lakes; or it may have for its ancestor a fresh-water crustacean; the genus *Candona* would be that which it most resembles, though nevertheless very dissimilar. The field of hypotheses remains open upon this point.*

A Microscopic Trap for a Rover.—Mr. F. A. Bedwell describes in the 'Midland Naturalist' a very useful contrivance to keep rotifers and other lively things within the field of view. A friend had sent him some specimens of *Hydatina senta* which he was anxious to examine with a high power. He says:—"I first tried my usual cell, a ring of microscopic glass, the very thinnest I can get (and answering to the No. 6 on the adjustment collar of the $\frac{1}{8}$), with a piece of glass as thin as itself over it. This prevented the whirligig performance, but rest was out of the question, and following even Hydatina's charms under a $\frac{1}{4}$, gets monotonous when you are always *only just catching her up*. So I tried an old idea in a new form. I took a flat glass slide and dropped two Hydatinas on it, with a small drop of water about half an inch in diameter. Upon this drop I laid some *cotton wool*, frayed out so as to be much diffused in space. I then put the thin sheet of glass on that, gave the sheet a touch with a needle to set the capillary attraction up, and Hydatina's gambols were over. I used an $\frac{1}{8}$ to examine her easily."

High-angled Objectives for Histological Work.—In his address to the Dunkirk (U.S.) Microscopical Society, Professor J. Edwards Smith strongly advocates for histological investigations objectives of very

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* 'Bibl. Univ.,' Oct. 15, 1877. 'Arch. des Sci.,' p. 334. 'Ann. Nat. History,' Feb. 1878.

wide ("plus 180°") angle of aperture, and in support of his view refers to an experience in which a friend with an English low-angled glass (50° to 70°) showed "Nasmyth's membrane" in a section of human tooth, which the glass of higher aperture proved to be an optical illusion only. "We often hear the remark," says the Professor, "that wide-angled glasses are just the thing for the display of lined objects, surface markings, diatoms, &c., but that, owing to their short focal length and limited working distance, the trouble attending the adjustment of collar, and in general the difficulties pertaining to their use, they are unsuited to the purposes of the histologist; while, on the contrary, low-angled glasses of greater working distance, requiring no skill in management, are the tools with which the real work of the microscope has been and will continue to be done; and such are fondly termed good, honest, and reliable 'working glasses.' I can never listen to this line of argument without entertaining the suspicion that sloth and inactivity lie at the bottom. We never hear astronomers complain of the care they are compelled to use in instrumentation; on the contrary, they pride themselves on the accomplishment of being able to work instruments requiring a great amount of skill and precision in manipulation. The objectives of short working distance originated years ago, when German pathologists were in the habit of using common window-glass to cover their mounts, and at that time the extremely thin glass now so easily procurable was unknown.

"A vast amount of work *has* been done with these 'honest and reliable working glasses,' and will have to be done over again; and this revising work is now in progress."

The Professor also refers to a case in which a sample of urine, from a child supposed to be suffering from a disease of the kidneys, appeared, when examined with a low power ($\frac{1}{5}$, of 70° aperture), to be in every respect healthy, "but on further examination with a wide-angled glass, and with an amplification of nearly 4000 diameters, it was found to be literally swarming with vibriones."

*New Process of Colouring Microscopic Preparations with a Picro-aniline Solution.**—Whilst engaged on the normal structure of the general lymphatic system, I had occasion to communicate to my colleagues of the Société medico-physique of Florence the good results which I had obtained in my investigations (better than by any other colouring matter) by a solution of *aniline blue and of picric acid.* I was unable at that time to enter much into details concerning this new and most simple method of staining, having only experimented upon a single tissue, that of the lymphatic system. Now, however, after having, together with Dr. Brigidi, made a large number of observations upon almost all the different tissues, I can speak about the method with more detail, and recommend it to those who are occupied with histological studies.

The two substances which I recommend for producing a very beautiful green colour have been already employed for some time in

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* Dr. A. Tafani, in the 'Journal de Micrographie.'

histology to colour tissues, both normal and pathological. Yet I do not find that anyone, until we did so, made use of these two reagents simultaneously, so as to obtain a composite colour different from that which each produced separately. Everyone knows, indeed, how soluble aniline blue is used as a matter of preference, and to save time, to colour elements and tissues which have been previously submitted to the hardening action of alcohol and chromic acid, although more time is required for those which have been submitted to the action of the latter reagent.

It is also known that certain tissues, such as those of the spleen and the lymphatics, and the cerebral and spinal nervous tissues, retain their colour better and with more elegance when aniline blue is used; that the preparations thus coloured do not lose the tint which they have acquired by the addition of the acids, whilst alkaline solutions and even glycerine affect them in time. A colouring matter possessed of such advantages is, however, but little employed compared with others, such as carmine, hematoxyline, &c.; and I believe the reason to be that preparations coloured by means of aniline blue, although very elegant, do not show all their details so well differentiated and so plainly as can be done with other processes, for example, with picro-carminate. Blue staining, in general, but particularly that produced by aniline blue, will not allow histological forms to be defined in all their details. I might almost say that the contours fail to be recognized, which prevents our distinguishing in a tissue rich in cellules the limits of the various elements.

It is besides well known that picric acid (in a saturated solution) colours the morphological elements and not the amorphous substances (Robin). It follows from this that the tissues which have been submitted to its action take a beautiful yellow sulphur tint, and do not in any way lose the distinctness of their outlines. This is owing to the fact that picric acid is a reagent which does not precipitate in a granular form the substances forming the tissues or elements on which it is made to act, whilst the contours of the nuclei, the nucleoli, the granulation, and the cell-walls do not disappear. Moreover, the action of picric acid is not like that of chromic acid, which enters into combination with the substances upon which it reacts (Ranvier); and it also constantly happens that coloured preparations, after being hardened by the latter acid, are completely deprived of their colour by repeated washings with water. The action of picric acid on tissues is therefore much less detrimental than that of chromic acid.

Whilst then the colouring properties of aniline and picric acid, when they act separately, are sufficiently well known, no one has until now (at least so far as I know) employed these two substances at the same time and on the same tissue, so as to obtain a different tint by their reciprocally modified action, and giving rise to some important peculiarities, especially in certain special tissues.

The idea of using picric acid in combination with another substance to obtain a third, unlike it, and whilst partly possessing the properties of the component substances, also some other new properties resulting from the mixture, is certainly not new, if we refer to Schwarz, who advised the mixing of picric acid with carmine in studying the unstriated muscles of the intestines, or to the picro-carminate of Ranvier, now so well known. I may add also that it has been suggested that a green stain might be obtained with picric acid dissolved in glycerine by the addition of a certain quantity of a decoction of logwood and the neutral chromate of potash, in the proportion of 1 part to 1000.

I avail myself, however, of picric acid mixed with soluble aniline blue to obtain a green tint of considerable delicacy, homogeneous as far as the eye can detect, and which serves to bring out in relief the smallest details which are presented by the tissues and their elements. This green stain is easily obtained, in a comparatively short time, either by subjecting the preparation to be stained to a solution in water of soluble aniline and picric acid, or first to a solution of aniline and then to another of picric acid. In whichever way these colouring matters are employed, an effect is obtained equally quick and satisfactory. The solutions, whether of picric acid or aniline, ought to be saturated, which can be done without difficulty by leaving an excess of each substance at the bottom of the vessels in which the materials are placed to dissolve. In this way we are always sure of employing only saturated solutions. When it is wished to make use of the picro-aniline solution, 100 cubic centimetres, for example, should be taken of the saturated aqueous solution of picric acid, and into it should be poured 4 or 5 cubic centim. of the blue liquid also saturated. The resulting solution admirably stains a preparation of the lymphatic glandular system in the space of a few minutes. If it is desired to employ the two substances separately, keep the preparation in the aniline solution for a few minutes, and afterwards place it in the picric acid. In working thus we can see that the preparation is not stained too much by the aniline, and to this end it is well to take it out as soon as it has acquired a light sky-blue tint. By taking it out at this point one is always sure that it will show the nuclear elements sufficiently coloured, whilst the protoplasmic parts and others will be only very slightly stained. By waiting, on the contrary, till the preparation has taken a dark blue tint, the nuclei will be very deeply stained and the other parts rather deeply also, so much so that on submitting it afterwards to the staining action of the picric acid it becomes confused and obscure. The preparations which have been treated with the aniline solution, with the precautions indicated above, and then placed in picric acid, pass in the course of about fifteen minutes from sky blue to a delicate green. After this treatment the tissues show the nuclei both free and cellular sufficiently stained with green, the protoplasm and the fibres coloured pea-green, though faintly and with a delicate shade. Since the staining by the aniline produced by the first treatment was less in these parts, the yellow colour predominates over the blue, whence there results a lighter and more delicate tint.

Similar results are obtained by making a picro-aniline solution act on the different tissues. It is possible to stain with great advantage not only fresh tissues, but also such as have been subjected to the action of different hardening reagents, such as alcohol, chromic acid, bichromate of potash, &c.

Microscopical preparations obtained by these processes may be preserved like others in fluids or balsam. It should be observed, however, that picric acid, being, as I have said, soluble in water and in alcohol, might easily be removed from the preparations upon which it has been made to act. To prevent this inconvenience it is important that the glycerine used to preserve the preparations should be slightly tinged with picric acid, and if balsam is used it is necessary to dehydrate the preparations in alcohol containing also a small quantity of the same acid in solution. In the latter case, after this treatment, the preparation may at once be placed in oil of cloves or turpentine without fear of the staining suffering from it. I would likewise observe here that if it is intended from the first to mount the preparation in balsam, the operation may be abridged by transferring the preparation immediately from the solution of aniline blue, in which it has acquired the tint I have indicated above, to a bath of alcohol to dehydrate it, the alcohol containing $\frac{1}{2}$ per cent. of picric acid in solution.

With the picro-aniline solution not only may different tissues be stained according to the ordinary process, i. e. by plunging the preparation into it, but interstitial injections may be made with it, and small artificial œdemata produced with Pravaz's syringe. By operating thus, for example, on a lymphatic gland, the colouring matter can be made to penetrate into the cavernous system where the endothelial cellules may be recognized lightly coloured with green, the characteristics of which, already well described by Professor Bizzorero, are seen with more clearness than with any other reagent. If a small œdema be produced under the skin of the groin in a rabbit or guinea-pig, the connective cellules and the fibres between which they are situated may be studied to perfection, as Renaut has done, by means of eosine, which is soluble in water. The picro-aniline solution, finally, may be very well employed in interstitial injections intended to show the relation between the cellule connectives, especially when the picric acid instead of being dissolved in water is dissolved in one-third part of alcohol.

The preparations thus obtained are not affected by the weak acids, acetic phenic, diluted chlorohydric &c., whilst alkaline solutions rapidly destroy their beautiful outline. The preparations, mounted in fluids or dry, with the precautions mentioned, preserve their stain for a very long time, for I have some which have undergone no alteration for more than a year.

The picro-aniline solution (which is specially to be recommended for the study of the lymphatic glandular system and for the retina) does also very well for other normal or pathological tissues. Thus I have preserved some complete sections of the medulla oblongata stained by this method, which for clearness and elegance leave nothing to be envied in those produced by carmine.

Amplifiers.—In an article on the "Amplifier," by Dr. Devron, in the 'American Journal of Microscopy,' he says :—"The Tolles' amplifier used on a large compound microscope, with lenses of various makers, of

$\frac{1}{10}$, $\frac{1}{16}$, and $\frac{1}{20}$, caused resolutions on the Nobert 19th band-plate, which without it at the same time and with the same illumination could not be seen with the same objectives; with that increased resolution the loss of light was not appreciable. Its value was made quite apparent by two photographs showing the resolution of *Amphipleura pellucida*, one by a $\frac{1}{25}$ and the other by a $\frac{1}{12}$ objective, the latter with the amplifier. The resolution into transverse striæ in both photographs and their appearance is so similar, that were they not numbered I could not tell which was obtained by the $\frac{1}{25}$ objective."

Penetration.—The following note from 'Le Microscope,' by Dr. J. Pelletan, p. 55, states a fact that is generally unknown, but which ought to be known to everyone who works with the microscope: "From a purely theoretical point of view an objective with penetration is in reality a defective objective." My experience is that there is not one in a thousand of the users of the instrument—especially the histologists—but have the idea, and their opinions are governed by that idea, that an objective that will show at one sight (or focussing) all the strata or planes in a section of a tissue $\frac{1}{50}$ or $\frac{1}{100}$ of an inch thick, or, in other words, one that has great penetrating power (better defined by the optician's term, "depth of focus"), must be the *best* and most important objective that can be made. Whereas it can be demonstrated that such depth of focus is optically incompatible with the best definition, which is the quality above all others desirable in a lens.

Depth of focus is a quality desirable in certain cases and for some purposes; the objectives for such use should be made expressly for that property, and the purchasers of such ought not to expect them to be capable of the higher histological work of modern microscopy.

There is, of course, a *wide* difference in definition of objectives that possess depth of focus. On the other hand, *all* objectives that are without that quality do not have the maximum defining power.*

The Genus Ligula.—M. Donnadieu holds that all the species described by authors as forming this genus are only the different phases of development of the same species, or the same parasite found in different animals, the so-called genus being simply a species of the genus Dibothrium—the *Dibothrium ligula.*

Nutriment of Bacteria.—MM. Dupont and Hoogewerff, of Rotterdam, have investigated the chemical constitution of the materials that nourish bacteria. Test tubes, like those used by Cohn, were filled with 20 c.c.m. of the nutrient fluid, and two drops of bacterium fluid, made with decomposing beans or peas, were added; the tubes having been first deprived of any atmospheric dust by hot water. Care was taken that the distilled water employed contained no organisms. Following Mayer, they prepared a normal nutrient fluid with 1 per cent. acetate of ammonia, 0·5 per cent. phosphate of potash, 0·5 per cent. sulphate of magnesia, and 0·05 per cent. phosphate of lime. As Mayer stated, they found the most important ingredient to

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* Carl Reddots, in 'American Journal of Microscopy.'

be phosphate of potash, and that the magnesian sulphate might be omitted without hindering the bacterium development. The following carbon compounds were tried in lieu of acetate of ammonia in the nutritive fluid. One per cent. of carbonate of ammonia gave no development; 1 per cent. of urea and the same of ethyl-urea no development; 1 per cent. formiate of ammonia, no bacteria, but some mycelium; 1 per cent. formiate of potash and the same of ammonia, bacteria development; 1 per cent. oxalate of ammonia, no development; 1 per cent. neutral acetate of ammonia, development; 1 per cent. of the acid acetate, no development; 1 per cent. acetamid, development; the same with 1 per cent. of glycocoll; no development with 1 per cent. of sulphate of anilin. The authors were led to the conclusion that only those carbon compounds served as food for bacteria which contained "carbon atoms not united with two of their affinities to oxygen." *

Bacteria as Parasites in Splenic Disease.—M. H. Toussaint has communicated fresh remarks on this subject to the French Academy, his object being to show that those who have attributed the disease to a virus, and not to the bacteria, are in error. Referring to a previous paper, he states that a rabbit dying after inoculation with blood containing the bacteria dies in consequence of the obliteration of the capillaries of essential organs, such as lungs and brain. Most of the flexuous capillaries of the economy are filled with bacteria at the moment of death. This effect is most readily observed in the choroid and retina of albino rabbits. He claims to have demonstrated that when fresh bacteria blood is received in tubes and preserved from contact with air and from putrefaction, it loses its contagious properties in six or eight days, or sooner if kept at a temperature of 38° to 40° C. A virus does not behave in this way. Such a method would be adopted to preserve it. Filtration of bacteria blood, fresh and defibrinized, through a filter composed of eight sheets of paper suffices to deprive it of its contagious elements. This filter allows the granulations, and even some white corpuscles to pass, but it retains all the bacteria. Such a filtration allows a considerable quantity of virus elements to pass, but completely deprives bacteria blood of its contagious properties. The time elapsing between bacterium inoculation and the death of an animal may be regulated by the quantity injected and the pretended incubation period suppressed. In one rabbit 1½ cubic centimetres of the affected blood were injected, containing some 1500 millions of bacteria; in another 75 millions; and in a third 1500, the blood being diluted with water. The first died in seven hours, the second in twelve or thirteen, and the third in thirty-six hours. He describes many other experiments, all confirming the belief that the death is produced by the multiplication of the organisms and their obstructing the capillaries.†

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* "Der Naturforscher," March 9, 1878, copied from 'Maandblad vor Natuurwetenshappen,' 6 Jrg., No. 1.

† 'Comptes Rendus,' March 18, 1878.

BIBLIOGRAPHY.*

The fourth edition of Beale's 'Microscope in Medicine,' and the second edition of Martin's 'Manual of Microscopic Mounting,' have just been issued; also a work by Dr. Dudgeon, the 'Human Eye; its Optical Construction popularly explained.' In Paris has been published the first part of Professor Ranvier's 'Histology of the Nervous System,' and in Leipzig the fourth edition of Dr. Willkomm's 'Die Wunder des Mikroskopes oder die Welt im Kleinsten Raume.'

Van Heurck's 'Microscope applied to Botany.'—A new edition of this work is announced to be in preparation, considerably enlarged, and with the addition of a third part dealing exclusively with diatoms. M. Van Heurck's collection of diatoms is (according to Dr. Pelletan) one of the most important now existing, containing not less than 10,000 specimens. It includes all the types of De Brébisson, and the original collections of Walker Arnott, Eulenstein, and Kützing, without reckoning the numerous series of W. Smith, Grünow, Hantzich, Rabenhorst, &c. The collection of Kützing, which belonged to Eulenstein, was divided into two parts, of which one was sold to the British Museum, and the other, which Eulenstein reserved for himself, now belongs to M. Van Heurck.

The first volume of 'Science Lectures at South Kensington' contains the lecture by Mr. H. C. Sorby, F.R.S. (ex-Pres. R.M.S.) on "Microscopes."

The QUARTERLY JOURNAL OF MICROSCOPICAL SCIENCE for January contains:—

On the Hinged Teeth of the Common Pike. By Charles S. Tomes.

Note on the Movements of the Vibracula in Caberea Boryi, and on the Supposed Common Nervous System in the Polyzoa. By the Rev. Thomas Hincks, B.A., F.R.S.

The Development of the Cranial Nerves in the Chick. By A. Milnes Marshall, D.Sc., B.A., Fellow of St. John's College, Cambridge.

A Contribution to the History of the Embryonic Development of the Teleosteans. By Ed. Van Beneden.

On the Homologies of the Suspensor. By Sidney H. Vines, B.A., B.Sc., Fellow and Lecturer of Christ's College, Cambridge.

The Red Vascular Fluid of the Earthworm a Corpusculated Fluid. By E. Ray Lankester, M.A., F.R.S.

The Contractile Filaments of Amanita (Agaricus) muscaria and Dipsacus sylvestris. By Francis Darwin, M.B.

On Atmospheric Bacteria. By G. T. Dowdeswell, B.A. Cantab.

A Review of Reichenbach's Researches on the Early Development of the Fresh-water Crayfish. By T. Jeffery Parker, Associate of the Royal School of Mines.

For April:—

On the Phenomena accompanying the Maturation and Impregnation of the Ovum. By F. A. Balfour, M.A., Fellow of Trinity College, Cambridge.

Notes on the Structure and Development of Osseous Tissue. (From the Physiological Laboratory of University College, London.) By E. A. Schäfer.

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* See note on p. 79. The journals noticed will be found in the library.

Recent Researches into the Nature of Lichens. By Sidney H. Vines, B.A., B.Sc., Fellow and Lecturer of Christ's College, Cambridge.

On the Endothelium of the Body-cavity and Blood-vessels of the Common Earthworm, as demonstrated by Silver-Staining. By D'Arcy Power, Exeter College, Oxford.

On the Life-History of Bacillus anthracis. By J. Cossar Ewart, M.B., University College, London.

Experimental Contribution to the Etiology of Infectious Diseases, with special reference to the Doctrine of Contagium vivum. By E. Klein, M.D., F.R.S.

On the Nature of Fermentation. The Introductory Address delivered in King's College, London, at the opening of the Session, October 1st, 1877. By Joseph Lister, F.R.S., Professor of Clinical Surgery in, and Surgeon to King's College Hospital, &c.

The ANNALS AND MAGAZINE OF NATURAL HISTORY for January contains:—

Observations upon Professor Ernst Häckel's Group of the "Physemaria," and on the Affinity of the Sponges. By W. Saville Kent, F.L.S., F.Z.S.

On the Minute Structure of the Corals of the Genera Heliophyllum and Crepidophyllum. By Professor H. Alleyne Nicholson, M.D., D.Sc., F.L.S.

On two New and remarkable Species of Cliona. By W. J. Sollas, M.A., F.G.S.

On Wagnerella, a new genus of Sponge nearly allied to the Physemaria of Ernst Häckel. By C. Mereschkowsky.

For February:—

Notes on British Spiders, with descriptions of some new Species. By the Rev. O. P. Cambridge, M.A., C.M.Z.S., &c.

Mr. James Thomson's Fossil Sponges from the Carboniferous System of the South-West of Scotland. By H. J. Carter, F.R.S.

Position of the Sponge Spicule in the Spongida, and Postscript on the Identity of Squamulina scopula with the Sponges. By H. J. Carter, F.R.S.

For March:—

On the Genus Palœacis, and the Species occurring in British Carboniferous Rocks. By R. Ethenge, jun., F.G.S., and Professor H. Alleyne Nicholson, M.D., D.Sc.

Note on Selaginopsis (= Polyserias Hincksii, Mereschkowsky), and on the Circumpolar Distribution of certain Hydrozoa. By the Rev. A. M. Norman, M.A.

Studies on the Hydroida. By C. Mereschkowsky.

For April:—

On the Genus Haliphysema, with description of several forms allied to it. By the Rev. A. M. Norman, M.A.

On the Architectural Achievements of little Masons, Annelidan (?) and Rhizopodan, in the Abyss of the Atlantic. By the Rev. A. M. Norman, M.A.

On New Species of Hydractinidæ, Recent and Fossil; and on the Identity in Structure of Millepora alcicornis with Stromatopora. By H. J. Carter, F.R.S.

HARDWICKE'S SCIENCE-GOSSIP for January contains, under the head of Microscopy:—

An Easily-made Cell. The 'Monthly Microscopical Journal.' The Spontaneous Generation Controversy. Sphæraphides. Birth of Vinegar Eels. The late Dr. Beatty. Cleaning Slides. To Clean Old Slides. To Preserve Glass Slips Ready for Use after Cleaning. How to Clean Thin Covers.

For February:—

A Plea for the Microscope as a Toy. Actinocyclus Berkleyi. Researches among the Sponges. Mounting Marine Algæ. The Quekett Microscopical Club. Coloured Oysters. The Spore-producing Power of Fungi. Parasitic Algæ.

For March:—

Volvox globator. Cleansing Old Slides. Improvement in Microscope-stands. Plant Crystals. Habirshaw's Catalogue of the Diatomaceæ. Microscopic Life of the Carboniferous Limestone.

For April:—

The 'American Microscopical Journal.' Machine for Mounting. A New Posting-box for Slides. Actinocyclus Berkleyi. Sap Crystals. Cleansing Diatomaceæ. The Resolution of Diatom Tests.

NATURE for the 21st and 28th March contains articles on the "Sources of Light" and "Reflection of Light," "from a forthcoming volume of the 'Nature Series'—'Light: a Series of Simple, Entertaining, and Inexpensive Experiments in the Phenomena of Light, for the Use of Students of Every Age. By Alfred M. Mayer and Charles Barnard.'"

The POPULAR SCIENCE REVIEW for April contains an article by Mr. W. Saville Kent, F.L.S., entitled "A New Field for the Microscopist" (the Flagellate Protozoa).

The QUARTERLY JOURNAL OF SCIENCE for April contains:—

On the Movement of Microscopic Particles suspended in Liquids. By Professor W. Stanley Jevons, LL.D., M.A., F.R.S.

The JOURNAL OF THE QUEKETT MICROSCOPICAL CLUB (No. 35) contains:—

The Ordinary Condenser Improved, or "Circular" Illumination Superseded. By W. K. Bridgman, L.D.S.

The President's Address, together with the usual Proceedings, the Committee's Report for 1877, and List of Members, Rules, &c.

The AMERICAN JOURNAL OF MICROSCOPY AND POPULAR SCIENCE for January contains:—

Description of a New Species of Argulus. By D. S. Kellicott.
On a New Rhizopod (*Lobularia marina*). By Professor R. Hitchcock.
Cox's Self-centering Turn-table.
Bullock's New Microscope.
Mounting on Wax.
The New York Microscopical Society.
Fraudulent Lenses.

For February:—

Rivet's Microtome and its Use. By Dr. Johannes Grönland. (Translated from the 'Zeitschrift für Mikroskopie.')

Elementary Papers on Objectives and some Accessories (*continued*). By Professor Hitchcock.—II. Cover Correction.

Discursory Thoughts relating to the Use and Abuse of the Microscope. An Address delivered by Professor J. Edwards Smith before the Dunkirk Microscopical Society, October 31st, 1876.

The Amplifier. By Gustavus Devron, M.D.

For March:—

The conclusion of Professor J. Edwards Smith's 'Discursory Thoughts.'
High-angled Objectives, with Wenham's Binocular.
The Birth of a Tree-hopper. By Rev. J. L. Zabriskie.
Keith's Heliostat.
A Trap for Catching Diatoms and Animalcules.
Finishing Slides.
The Combination Whirling Table.
A New Marking Box for Slides.

The AMERICAN NATURALIST for January contains:—

The Microscope as a means of Examination of Rocks and Fossils. By Dr. R. Fritz Gaertner.

For February:—

The Postal Club, a new Mailing Box for Slides.

For March:—

The Transformation of the Red Mites. By Professor C. V. Riley.

For April:—

A continuation of Dr. Fritz Gaertner's paper on the Microscope as a means of Examination of Rocks, &c., Amœba proteus, by Professor Joseph Leidy; and a New Method of Opaque Mounting, by C. C. Merriman.

The JOURNAL DE MICROGRAPHIE (published at Paris) for January contains:—

The Embryogenous Cell. By Professor Balbiani.

On the Anatomy and Physiology of the Retina. By Professor Boll. (*Continuation.*)

On Foreign Microscopes (the English Microscopes). By Dr. J. Pelletan. (*Continuation.*)

Observations on the Termination of the Motor Nerves of the Striated Muscles of the Torpedoes and the Rays. By Professor Ciaccio.

The Dissection of the Nervous System of the Fishes. By Professor Emile Baudelot.

On Diatoms in Coloured Liquids. From the Bulletin of the Belgian Microscopical Society.

A Review of M. A. L. Donnadieu's 'Contribution to the History of the Genus Ligula;' also of the Microscopical Analysis of Rocks and the Cavities of Minerals, by M. A. Renard.

A Note by the Editor (Dr. Pelletan) on Mr. Tolles' $\frac{1}{6}$ Objective.

For February:—

On Parthenogenesis. By Professor Balbiani.

On the Anatomy and Physiology of the Retina. By Professor Boll. (*Continuation.*)

Observations on the Termination of the Motor Nerves of the Striated Muscles of the Torpedoes and the Rays. By Professor Ciaccio. (*Continuation.*)

Note on the Termination of the Nerves in the Electric Apparatus of the Torpedo.

A "Free Translation" of Mr. Stephenson's Paper on Professor Abbe's Theory of Microscopic Vision, which appeared in the 'Monthly Microscopical Journal' for February, 1877, with Notes by the Editor.

The Bacillaria with a Siliceous Envelope, or Diatomaceæ. By Kützing. (*Continuation.*)

Analysis of Two Memoirs. By Dr. O. Brefeld and Dr. L. Nowakowsky, on the genus Entomophthora.

On a New Micro-lepidoptera (*Albinia Wockiania*, Briosi.)

Reviews of Ranvier's 'Histology of the Nervous System,' and of Schmidt's 'Atlas der Diatomaceen-Kunde.'

For March:—

The Lymphatic Hearts. By Professor Ranvier.

On the Anatomy and Physiology of the Retina. By Professor Boll. (*Conclusion.*)

Observations on the Termination of the Motor Nerves of the Striated Muscles of the Torpedoes and the Rays. By Professor Ciaccio. (*Continuation*)

On Foreign Microscopes (the American Microscopes). By Dr. J. Pelletan. (*Continuation.*)

The Siliceous Fossil Beds of Auvergne employed in the Preparation of Dynamite. By Drs. Leuduger Fortmorel and Paul Petit.

A Further Note by the Editor on the Revivification of the Diatoms.

On a New Mode of Colouring Microscopic Preparations with a Picro-aniline Solution. By Dr. A. Tafani.

On a Photographic Microscope. By Professor C. Fayel.

A Review of Professor Eaton's 'Ferns of North America,' and Notice of the Editor's forthcoming 'Manual of Normal Histology.'

The Berlin ZEITSCHRIFT FÜR MIKROSKOPIE for January contains the continuation of Dr. E. Kaiser's article "On the Development and Present Position of Microscopy in Germany;" of the translation of Dr. Pelletan's "Foreign Microscopes," from the "Journal de Micrographie;" also an abstract of Dr. Koch's "Investigation, Preservation, and Photographing of Bacteria."

For February:—The continuation of the translation of Dr. Pelletan's "Foreign Microscopes;" "On Micro-photography," by Dr. S. Th. Stein; "On the Collection and Observation of Microscopic Objects on Travels and Excursions," by Dr. E. Bouché (*continuation*); an abstract of an article by Dr. A. Tschamer "On the Nature of Hooping Cough," and one by Dr. Woodward "On the Use of Artificial Light in Micro-photography."

No number of the ARCHIV FÜR MIKROSKOPIE ANATOMIE for 1878 has yet been received.

SIEBOLD AND KOLLIKER'S ZEITSCHRIFT FÜR WISSENSCHAFTLICHE ZOOLOGIE for January contains the first part of an article by Bütschli, "On the Flagellata and some Allied Organisms," illustrated with five coloured plates.

In the number for March is the fourth part of Schulze's 'Investigations on the Structure and Development of the Sponges—The Family of the Aplysinidæ" (with four coloured plates).

PROCEEDINGS OF THE SOCIETY.

King's College, *March* 6, 1878.

H. J. Slack, Esq., President, in the chair.

The minutes of the preceding meeting were read and confirmed.

The President announced that the first number of their new Journal would be in the hands of the Fellows in the course of a few days, and that he hoped, for a beginning, that it would give satisfaction.

A list of donations to the Society during the past month was read by the Secretary, and the thanks of the meeting were voted to the donors.

Mr. Charles Stewart gave a description of a supposed new coral, belonging to the genus *Stylaster*, said to have been obtained from a small island in the vicinity of Tahiti, where it was considered to be exceedingly rare. After pointing out the difference between various genera of corals, Mr. Stewart proceeded to describe and figure the species under notice, and to compare it with other known forms of the same genus. Specimens exhibited under the microscope in the room were objects of much attention at the close of the meeting.

The thanks of the meeting were unanimously voted to Mr. Stewart for his communication. (The paper will be found at p. 41.)

The President said they had another paper "On a new Operculated Infusorian from New Zealand," by Mr. Hutton. It would perhaps be remembered that in the first volume of the 'Monthly Microscopical Journal' (p. 289) there was a short paper by Mr. W. S. Kent, "On some new Infusoria from Victoria Docks," in which he described a new species of Cothurnia, which had been discovered by Mr. Reeves, and which possessed a well-developed operculum. Mr. Charles Stewart having drawn in coloured chalks upon the black-board the species described and figured in Mr. Hutton's paper, the President observed that the animal discovered by Mr. Reeves carried the cover up with it when it came out of the cup, thus far resembling that described by Mr. Hutton, but the latter was remarkable for its forked bristles.

The President then proposed a vote of thanks to Mr. Hutton for his very interesting communication.

A paper by Mr. Adolf Schulze, "On a New and Simple Means of Resolving the finest Balsam-mounted Diatom Tests, with special reference to *Amphipleura pellucida*," was read by the Secretary.

The President said that Dr. Dixon had been kind enough to come down to the meeting to exhibit the mode of illumination which was described in the paper, and invited that gentleman to make some observations upon the matter.

Dr. Dixon said he had really no remarks to make, for the process was so simple that he had great difficulty in finding anything to say about it.

The President inquired if Dr. Dixon found that glycerine would do as well as castor-oil with the Wenham illuminator.

Dr. Dixon thought that glycerine would not answer the purpose so well. The greater viscidity of castor-oil allowed a greater range of focus; and for the same reason it would not so readily run off the face of the illuminator.

Mr. Stephenson said he had tried this and other immersion plans of illumination, and had resolved without difficulty Amphipleura and other difficult diatoms in balsam. He thought the fact was very often overlooked, that with a dry condenser of the widest angle it was hardly possible to resolve the fine lines of balsam objects; but with an immersion condenser it would be quite possible; and he might say that the resolving power of a Zeiss's immersion objective would be at least 10 per cent. greater on a balsam object than that of a dry lens of 180° on an object in air.

Mr. T. Curties said that Mr. West, who had been very successful in producing Lissajou's curves microscopically upon glass, was present, and had brought some specimens, which were exhibited under microscopes in the room.

Mr. West said that most persons were familiar with these curves as drawn upon paper, so that he need say very little in the way of describing them. He had been successful in drawing them upon glass upon a very small scale, and he was told that they possessed some value as test objects. He believed he owed much of the success to the excellence of the diamond point which had been supplied to him by Messrs. Beck. The appearance of solidity in many of the figures had attracted attention, and was rather curious. The chief difficulty in exhibiting these objects was in obtaining a proper kind of illumination.

In reply to a question from the President, Mr. West stated that these figures were drawn directly upon the glass.

The President said that, in returning to the old practice of having tea and coffee at the close of their meetings, they hoped to somewhat increase their social character, and for this purpose they should endeavour to get the business of the evening over by nine o'clock, so as to leave a little time afterwards for conversation and the exhibition of any objects which might be brought by any of the Fellows. He hoped, therefore, that if any Fellow of the Society had objects which he wished to exhibit or to ask questions about, he would bring them down to the meetings. At their scientific evenings they should adhere to the plan which they had found to work so well—that of bringing objects of special interest which could not be seen elsewhere; but the field of research was so great, that it was quite likely that a person well acquainted with one particular branch might find objects of another kind which were unfamiliar to him, and about which he might be glad to have the opinions of others at the ordinary meetings.

The following gentlemen were elected Fellows of the Society, viz.:—John Davis, Esq.; George Raynor, Esq.; Francis Boughton Kyngdon, Esq.; and the Rev. G. E. Watts, M.A.

KING'S COLLEGE, *April* 3, 1878.

H. J. Slack, Esq., President, in the chair.

The minutes of the preceding meeting were read and confirmed.

The list of donations was announced, and the thanks of the Society returned to the respective donors.

The President gave notice that upon the recommendation of Mr. Stephenson, Dr. Matthews, and Mr. Crisp, in accordance with the fifteenth bye-law, and with the approval of the Council, Professor Abbe, of Jena, had been duly nominated an Honorary Fellow of the Society, and that accordingly the Professor's name would be suspended in the usual way and submitted for election at the meeting of the Society in May.

Mr. J. W. Stephenson read a paper "On a New Large-angled Immersion Objective without any Adjustment Collar."

The President said that Mr. Stephenson had been kind enough to bring down to the meeting the object-glass which he had described in his paper, and another of the same pattern belonging to Mr. Crisp was also in the room, and it would be, no doubt, interesting and useful to examine them after the meeting.

Mr. Frank Crisp said that he could bear testimony to two, at any rate, of the advantages of the new objective, viz. the great increase of light, and the facility with which it could be at once adjusted to the object, being without correction collar. It might be interesting to observe, by way of history, that the use of oil in Mr. Stephenson's objective had nothing in common with the use of it for microscopical purposes by Sir David Brewster in 1810—before the application of achromatism to the microscope. His plan was to place the object to be observed at the bottom of a small glass cylinder filled with oil, and the objective was focussed upon the object through the oil. There was thus a convex lens of crown glass, and the oil acted as a concave lens. If the proper curves were taken for the convex lens, there would in the result be (theoretically) an achromatic combination.

Dr. Matthews thought that the discrepancy observed as to the tables of refractive indices, to which allusion had been made in the paper, might be due to the age of the oil. All essential oils underwent oxidation, which caused them to become thicker and more refractive, and this might account for the discrepancy.

The President inquired which of the essential oils was least subject to this kind of alteration.

Dr. Matthews was hardly prepared to say without looking into the subject more closely, but he believed the worst was turpentine.

The President said it was clear that the chief consideration in the case of this objective was to get the proper kind of oil.

The thanks of the meeting were voted to Mr. Stephenson for his paper.

Mr. Frank Crisp read a paper "On the Present Condition of Microscopy in England."

The President thought that Mr. Crisp had hardly been quite fair to Dr. Pigott in the course of his observations. Dr. Pigott only wanted to prove that the best object-glasses had some small but important residual error, and could be improved by the use of the means which he proposed.

The thanks of the Society were voted to Mr. Crisp for his paper.

The President announced that they had received two pamphlets on diatoms from Professor Cleve, and that a number of specimens in illustration had been sent for examination. Dr. Millar had also brought with him a singularly beautiful species of sponge, *Acarnus innominatus* Gray, and Mr. Curties exhibited a number of specimens of stained tissues.

Donations to the Library since February 6, 1878:

	From
Nature. Weekly	*The Editor.*
Athenæum. Weekly	*Ditto.*
Society of Arts Journal. Weekly	*Society.*
Bulletin de la Société Belge de Microscopie	*Ditto.*
Bulletin de la Société Botanique de France	*Ditto.*
Quarterly Journal of the Geological Society	*Ditto.*
Saint Louis Medical and Surgical Journal, Feb. 1878	*Editor.*
Proceedings of the Literary and Philosophical Society of Liverpool, 1876 and 1877	*Society.*
Journals of the Linnean Society	*Ditto.*
Brooke's Introduction to Crystallography	*F. Crisp, Esq.*
Catalogue and Description of the Rarities belonging to the Royal Society. By N. Grew, M.D., 1681	*Ditto.*
Amphitheatrum Zootomicum. By M. Bernardo Valentine, 1720	*Ditto.*
The Microscopist. By Dr. J. Wythes, 1853	*Ditto.*
Dialogues on the Microscope. By Rev. J. Joyce	*Ditto.*
Two Papers on Diatoms from the Arctic Sea. By Prof. P. S. Cleve	*Author.*

John Naish Smart, Esq., and Thomas Bolton, Esq., were elected Fellows of the Society.

WALTER W. REEVES,
Assist.-Secretary.

JOURNAL

OF THE

ROYAL MICROSCOPICAL SOCIETY.

JULY, 1878.

I.—*The Structure of the Coloured Blood-corpuscles of Amphiuma tridactylum, the Frog, and Man.* By Dr. H. D. Schmidt, Pathologist of the Charity Hospital, New Orleans, La.

(*Taken as read before the* Royal Microscopical Society, *April* 3, 1878.)

Plate V.

(*Continued from p.* 78.)

Before further discussing in detail the observations relating to the structure of the coloured blood-corpuscles of the Amphiuma, I propose to give a brief description of the mode of their development from the colourless corpuscles. Their origin, or original development in the first stages of embryonic life, I had no opportunity to observe; for in those embryos which I fortunately obtained they were already completely formed.

As we may suppose that the metamorphosis of a colourless blood-corpuscle into a coloured one is not accomplished in a space

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EXPLANATION OF PLATE V.

Fig. 28.—Coloured blood-corpuscle of Amphiuma, treated with a 2 per cent. solution of boracic acid.

Fig. 29.—Coloured blood-corpuscle of Amphiuma, treated with the vapour of a 4 per cent. solution of osmic acid.

Figs. 30, 31, 32, and 33.—Coloured blood-corpuscles of Amphiuma, treated with a strong solution of hydrate of chloral.

Fig. 34.—Coloured blood-corpuscle of Amphiuma, treated with nitric acid vapour.

Fig. 35.—Coloured blood-corpuscle of Amphiuma, treated with nitric acid liquid.

Figs. 36 and 37.—Coloured blood-corpuscles of Amphiuma, treated with diluted nitric acid.

Fig. 38.—Coloured blood-corpuscle of Amphiuma, treated with ether liquid.

Fig. 39.—Colourless blood-corpuscles of adult Amphiuma.

Fig. 40.—Different forms of transition from the colourless into the coloured blood-corpuscles, met with in the blood of adult Amphiuma.

Fig. 41.—Colourless blood-corpuscles from the pulp of the spleen of adult Amphiuma.

Fig. 42.—Colourless blood-corpuscles and their transitory forms into the coloured corpuscles, met with in the blood of the very young Amphiuma.

[Fig. 43.

of time short enough for any observer to witness it under the microscope, the process of development or transition can only be studied by making certain deductions from the various transitory forms of these blood-corpuscles as they are met with in the blood of the animal.

In the blood of the adult animal, the primary form of the colourless blood-corpuscle seems to be a nucleus surrounded by a layer of granular protoplasm (Fig. 39, *a*). The nucleus represents a vesicle, distinguished by a distinct double contour, and containing a limited number of granules. Both contour and granules show a faintly greenish tint. The multiplication of the corpuscle takes place by a division of the nucleus, while it is still surrounded by the protoplasm (Fig. 39, *a* and *b*), though many instances are observed where the nuclei are set free by the dissolution of the protoplasm (Fig. 39, *c*), and hence a number of free nuclei are always met with in the blood. The transitory forms to be studied are represented in Fig. 40. The first (*a*) is a round nucleus, in which the inner contour of its wall is represented by a zone of minute granules of a greenish tint, appearing as if deposited upon the inner surface of the wall; in the interior of the body the usual granules are observed. The second form (*b*) represents a larger

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Fig. 43.—Coloured blood-corpuscle of the young Amphiuma.

Fig. 44.—Coloured blood-corpuscle with its protoplasm contracted, from the young Amphiuma.

Fig. 45.—Egg of the Amphiuma with embryo (natural size).

Fig. 46.—Embryo of Amphiuma, taken from the egg (natural size).

Fig. 47.—The same, slightly enlarged.

Fig. 48.—Coloured blood-corpuscles of the large Bull-frog; *a*, front view; *b*, side view.

Fig. 49.—A coloured blood-corpuscle of the same animal, in which a retraction of the protoplasm has taken place, exposing the membraneous layer.

Fig. 50.—Coloured blood-corpuscle of the Frog, with spinous elevations on its surface.

Fig. 51.—Coloured blood-corpuscles of the Frog, treated with water.

Fig. 52.—One of the same, treated subsequently with a weak solution of chromic acid.

Fig. 53.—Coloured blood-corpuscle of the Frog, treated with acetic acid vapour.

Fig. 54.—Coloured blood-corpuscles of the Frog, treated with a weak solution of chromic acid.

Fig. 55.—Coloured blood-corpuscles of the Frog, treated with a strong solution of hydrate of chloral.

Fig. 56.—Coloured blood-corpuscles of the Tree-frog; *a*, front view; *b*, side view; *c*, one with a portion wanting, as described in the text.

Fig. 57.—Coloured blood-corpuscles of the Tree-frog, treated with a weak solution of chromic acid; *a*, corpuscle with the protoplasm contracted in the form of a star; *b*, the protoplasm entirely contracted upon the nucleus; *c*, granular appearance of the protoplasm.

Fig. 58.—Infusorium found in the blood of the Tree-frog.

Fig. 59.—Coloured blood-corpuscles of Man; *a*, front view; *b*, side view.

Fig. 60.—Various forms of coloured blood-corpuscles of Man, produced by a partial contraction of the protoplasm.

Fig. 61.—Coloured blood-corpuscles of Man, exhibiting spontaneous motion.

Fig. 62.—Coloured blood-corpuscles of Man, treated with water.

body, with a clear border, limited by a fine though very distinct contour. The inner contour of the apparent wall is, as in the preceding form, represented by the outlines of the zone of granules, which here, however, is of greater breadth; while the outlines of the individual granules are considerably darker; the greenish tint of the zone is also more decided. There are no large granules nor a nucleus observed in the interior, though it may be supposed that they exist, but are hidden by the dark-bordered granules. The lighter tint of the body at its centre, compared with that at the periphery, is, of course, due to the difference of refraction existing in the rays of light passing through the body, the central rays being less refracted than those nearer the periphery. The third form (*c*), still larger than the preceding, encloses a distinct and perfect nucleus. The interior of the body appears to be completely filled with the dark-bordered granules of a now very decidedly greenish tint. When treated with water, these granules become very distinct, while those of the nucleus are dissolved, and the space occupied by the latter is rendered clear (*d*). Fig. 40, *e*, represents, lastly, a young coloured blood-corpuscle of an oval form and greenish tint. Though the nucleus contains a number of granules, it will be observed that the dark-bordered granules of the protoplasm have disappeared.

In examining the forms *a*, *b*, and *c*, it becomes obvious that they represent only different stages of development of one and the same body. But the question now arises, whether they began their development from a perfect colourless blood-corpuscle, or from a free nucleus. If developed from a colourless blood-corpuscle, that is from a nucleus, surrounded by a layer of protoplasm, the first step of the process must be a contraction of the latter upon the nucleus, and a condensation of its outer surface, which is shown by the even and distinct dark contour, represented in the drawing. The nucleus, of course, would at a somewhat later period assume an oval form, in order to represent that of the future coloured blood-corpuscle. In the course of development, the whole body would enlarge by the formation of new granules, and finally assume an oval form; at the same time the granules would disappear, and the greenish tint be changed into the yellowish colour of the mature coloured corpuscle. In regard to the greenish tint, we might ask, whether it is not due to the incipient formation of the hæmoglobin?

If, on the other hand, these forms arise from a free nucleus uncovered by protoplasm, the process must appear more complex; for then the granules would have primarily to be formed in the interior of the nucleus, and deposited upon the interior surface of its wall, while a new nucleus is developed from one of the granules of the old one.

In judging between the merits of these two explanations of the mode of development of the coloured blood-corpuscle, the first one might appear the most plausible and correct, if there remained no other phenomena to be accounted for. One of these phenomena is the presence of a considerable number of free nuclei in the circulating blood. Whether they are young nuclei, resulting from the division of older ones, subsequently surrounded by a layer of protoplasm, or whether they have been only deprived of their layer of protoplasm, is difficult to decide. At any rate, in the blood of very young animals about five inches in length, the colourless blood-corpuscles are to a very great extent represented by these free nuclei. In examining the numerous transitory forms of development, represented in Fig. 42, we observe some of these free nuclei at *a* and *c*, the one oval, the other round; *b* and *d* represent them in the act of division. Farther on at *e*, we meet with a round body limited by a dark single contour, and containing no granules whatsoever, but moreover distinguished by an opaque centre and periphery, which are separated by a clear space in the form of a zone. Presuming that this body arose by a transformation of a free nucleus, it may be supposed that the granules in the interior of this nucleus were at first dissolved into a homogeneous substance, fusing with the wall, by which process the double contour would disappear; and further, that subsequently a separation of this homogeneous mass into a central and peripheral portion took place, from which finally a new nucleus and the dark-bordered granules, seen in the more advanced stages of metamorphosis, were found.

Now it really matters not, whether this or the other explanation of the first stage of metamorphosis of the colourless blood-corpuscle into a coloured one be accepted as the correct one, as the resulting body in both instances consists of a mass of dark-bordered granules of a greenish tint, with a nucleus in its centre, and limited at the periphery by a distinct and dark contour. In the blood of the adult animal this body appears mostly round (Fig. 40, *b*, *c*, and *d*), while in that of very young animals it is oval (Fig. 42, *f* and *g*). The next stage of transition consists in the gradual disappearance of the dark-bordered granules (*i*, *k*, *l*, and *m*), and the appearance of a pale yellow colour in place of the greenish tint.

In the pulp of the spleen, enclosed, as in the higher orders of animals, in meshes formed by a delicate fibrous tissue, the same forms of colourless blood-corpuscles are observed as in the circulating blood (Fig. 41).

In the blood of very young animals the fully-developed coloured blood-corpuscles present the same characters as those of the adult. They are somewhat smaller, especially in breadth, and the nucleus appears more distinct, showing clearly its double contour (Fig. 43).

As has been mentioned before, chance favoured me in throwing a considerable number of the eggs of the Amphiuma into my hands, enabling me to examine the blood of the embryos contained within. It is not often that the nest of this animal is found; and as there are several characteristic points connected with its eggs, which may prove of some interest to the zoologist, I shall briefly mention them.

The Amphiuma chiefly inhabits the mud of low waters and ditches of the swampy lands along the coast of the Gulf of Mexico. Considering its eel-like form and minute rudimentary extremities, it might be supposed that its habits were entirely aquatic, and that, accordingly, its eggs would be deposited and hatched, like those of other Amphibia, as the Frog, upon the water. This is not the case; on the contrary, the resting place of the animal seems to be a subterranean hole with an entrance just above the margin of the water in the ditch or pool. In this hole it deposits its eggs. In most instances the nest is accidentally discovered, when a fresh ditch is dug in the vicinity of an old one. The animal is then found encircling the whole mass of eggs with its body. The number of eggs, from what I have learned from trustworthy witnesses, must be enormous; and judging from the expression, "a hatful," used by my friends in giving an idea of the amount, there must be at least a thousand or more in one nest. A small portion alone of the contents of a nest, sent to me by a friend, consisted of about two hundred eggs. Long before I saw these eggs myself, I had been told by some of my friends, among the German and French gardeners living in the vicinity of the lower parts of the city, and kindly supplying me with animals for my researches, that the eggs were attached to each other, resembling a string of beads or rosary. Not knowing any vertebrated animal,* the eggs of which were held together in this manner, the story, of course, excited my doubts, but proved to be true in the sequel. The form of the egg measures about 14 mm. in length to 11 mm. in breadth. The egg-membrane consists of two layers, the external one, being continuous, forms the mutual connection between the neighbouring eggs (Fig. 45). Both layers of the membrane are transparent in such a degree, as to allow the study of every part of the embryo within. A thin serous liquid fills up the interior of the egg, and the embryo, being heavier than the liquid, rests upon the lowermost portion of the egg, returning always to this position whenever the egg is suddenly turned. As is shown in the drawing, its body is curled,

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* Among the Invertebrata the same phenomenon is met with; in some varieties of *Limax*, a species of snail here, the connection is also formed by the outer layer of the egg-membrane passing from one egg to the other. These are the only instances known of a direct connection between the eggs. In some other snail families the eggs are found to be only *imbedded* in tubes or bands consisting of a mucilaginous material.

in order to adapt itself to the form of the space which encloses it. Liberated from the egg and put in water, the body of the embryo, with the exception of the tail, straightens itself. Fig. 46 represents one of these embryos under water, of the natural size; Fig. 47 represents an enlarged portion of it. How far these embryos were advanced in their development, the reader may judge himself from an examination of the drawings. I will only add that the greater part of the tissues still consisted of what we may call "embryonal cells"; of course of different forms and diameter. The spinal column was just beginning to be formed. The circulatory apparatus of the blood, as can be seen in the drawings, where the blood-vessels are represented in black, had very considerably advanced in development, for the rhythmical contractions and dilatations of the heart, represented by a prominence (Fig. 47) below the neck of the animal, were distinctly seen. The blood-vessels represented in black in the drawing, appeared in nature bright scarlet. While the head, neck, and posterior half of the body, owing to the commencing formation of the skin, was of a dark colour; the anterior portion, representing the future thorax and abdomen, was yellow, representing the remains of the vitellus, though abundantly supplied with blood-vessels. No trace of the development of the lungs or of any of the abdominal viscera could be discovered. The respiratory function was performed by two pairs of delicate leaf-shaped branchia, arising from the sides of the neck. Consisting entirely of large delicate embryonal cells, they were very transparent, offering not the slightest obstacle to the passage of the light during the study of the circulation of the blood. In fact, owing to the enormous size of the blood-corpuscles, as well as to the transparency of the membranes, the corpuscles could be distinctly seen as they were swiftly passing through the vessels, even through the egg-membrane, with a 1-inch objective, and illuminated with the daylight reflected upon the egg. The life of the embryos is very tenacious, for their blood may be seen still moving through the vessels of their branchiæ six hours after they were removed from the egg and kept in water. By covering the eggs with a damp cloth, the embryos within may be kept alive for five or six days.

As regards the blood-corpuscles of these embryos themselves, they have almost the same appearance as those of the fully-developed animal already described. The only difference to be noticed consists in a greater delicacy of structure, and in their smaller size, their long diameter amounting only to $\frac{56}{1000}$ mm.; their colour also is of a paler yellow. In some of these blood-corpuscles I have observed the nucleus in the act of division. Treated with water, they distinguished themselves from those of the adult animal by not parting so readily with their colouring matter.

But one of the most interesting facts which I observed in the blood of these embryos, and to which I wish to direct the attention of other observers, was *the entire absence of the colourless blood-corpuscles;* not a single one could be found. And this fact corroborates what I formerly asserted in my paper "On the Origin and Development of the Coloured Blood-corpuscles in Man," published in the 'Monthly Microscopical Journal' of February, 1874, namely, *that the blood of the embryo contains no colourless blood-corpuscles prior to the development of the spleen or lymphatic glands.*

The particular view regarding the structure of the coloured blood-corpuscles of *Amphiuma tridactylum,* which I formed after comparing the facts elicited by the microscopical examinations of these bodies, I have already partly exposed in the preceding portion of this paper. It corresponds in its chief points with that which I have entertained and expressed before. The following represents a summary of the conclusions to which I finally arrived.

The coloured blood-corpuscle in question, as well as that of other Amphibia, represents an organic cell, consisting in its normal condition of a homogeneous protoplasm, surrounding a nucleus. That part of the protoplasm forming the outer surface of the blood-corpuscle seems to be of a greater density than the rest. In consequence of this circumstance, a membrane-like stratum or layer (membraneous layer) is formed, possessing no *distinct* inner limitation, as would otherwise be indicated by the presence of a distinct second contour, but maintaining its connection with the underlying protoplasm by its homogeneousness of composition. In the fresh condition the membraneous layer is seen in the form of a clear, narrow border of a greenish tint. But when the protoplasm surrounding the nucleus and underlying the "membraneous layer" becomes dissolved, or otherwise altered by the action of water or other reagents, this layer assumes the appearance of a distinct cell-wall, characterized by the presence of a distinct double contour. The colouring matter (hæmoglobin) of the blood-corpuscle does not seem to be chemically united with the protoplasm, but to exist rather in the form of an intimate mixture with the latter, similar to that of the oxygen and nitrogen composing our atmosphere. In this form it exists, either equally distributed throughout the whole mass of the protoplasm, or, judging from my observation, represented in Fig. 13, perhaps only in the form of a stratum beneath the membraneous layer. The latter supposition remains an open question. Whether the hæmoglobin penetrates the membraneous layer I am not prepared to decide. The readiness with which the colouring matter escapes from the blood-corpuscles, even by the action of very weak reagents, such as water or some gases, seems to indicate that the mutual connection between the hæmoglobin and the protoplasm is of a feeble nature.

The membraneous layer of the blood-corpuscle seems to be endowed with a certain degree of elasticity, manifesting itself in the expansion and contraction observed when the blood-corpuscle is subjected to the action of water or other reagents. While the expansibility is but very slight, its contractility is considerable, as has been seen, when treated with a solution of hydrated chloral, chloroform liquid, or some other agents. While the protoplasm may be dissolved by water, dilute acetic acid, and some other reagents, it seems to undergo coagulation by the action of hydrated chloral, nitric acid, &c., assuming certain forms during this process.

The nucleus represents an oval vesicle, containing most probably a more or less dense liquid with a number of larger and smaller granules. After first expanding, these are finally dissolved by the action of water, causing at the same time a simultaneous increase in the volume of the whole contents, and an expansion of the wall of the nucleus. The liquid resulting from the dissolution of the granules may be rendered granular by the action of some acids. The nature of the granules and liquid contents of the nucleus is heterogeneous with that of the protoplasm of the blood-corpuscle, they being in most instances differently affected by one and the same reagent.

The manifold changes of form which some blood-corpuscles undergo are due to a contraction of the protoplasm; and as in almost every specimen of fresh blood some of these abnormal forms are met with, I am inclined to regard these changes as retrogressive; that is, as preceding the death or final disintegration of the blood-corpuscle.

The Coloured Blood-corpuscles of the Frog (*Rana pipiens*).—It is for the sake of comparison that I propose to enter into a discussion of the structure of the coloured blood-corpuscles of this animal, a subject which has repeatedly been studied and discussed by almost every prominent histologist. The very fact that frogs are found in almsot every country where histological science is cultivated, and that their blood, being easily obtained, has thus become a common object for microscopical examinations, prompts me to demonstrate that the phenomena observed on the coloured blood-corpuscles of these animals differ but very little from those observed on the blood-corpuscles of the Amphiuma, and that it is not the enormous size of the latter which alone renders these phenomena so conspicuous to the observer. For this reason it cannot but appear strange that some of the most prominent points relating to the structure of these bodies should have passed entirely unnoticed, and furthermore that such palpable phenomena should have given rise to fanciful theories and speculations as mentioned in the introduction of this article.

The coloured blood-corpuscles of the Frog resemble in form and structure, as well as in most chemical and physical properties, those of the Amphiuma; it is only in size that a very considerable difference exists between them. For while in the Amphiuma the length of these bodies ranges from about $\frac{70}{1000}$ to $\frac{80}{1000}$ mm., they only attain a length of $\frac{30}{1000}$ to $\frac{35}{1000}$ mm. in the Frog. And even in the latter their size depends to a certain extent upon the average size of the particular species. Thus I have found the largest corpuscles in the blood of those giants among the frogs (Fig. 48, *a* and *b*), the bull-frogs, which attain a length of from twelve to thirteen inches, measured from the nose to the toes.

The difference of colour which I described to exist between the border and the rest of the blood-corpuscle of the Amphiuma, may be equally observed, not only on the blood-corpuscles of the Frog and other Amphibia, but also on those of Birds. While the main part of the corpuscle, as will be remembered, is of a dirty yellow, the border is distinguished by a greenish tint; and although there exists no distinct line of demarcation between the two colours, representing an inner contour, this nevertheless appears under certain conditions, just as in the case of the blood-corpuscles of the Amphiuma. The various changes of form which we have been noticing to take place in the latter in their fresh condition, and which depend on a contraction of the protoplasm, do not occur to such an extent on the fresh blood-corpuscles of the Frog. Not unfrequently, however, corpuscles are met with, in which by a contraction of the protoplasm this part of the corpuscle has in some places become separated from the membraneous layer. Here a vacuum is left between the latter and the retracted protoplasm (Fig. 49), in consequence of which the membraneous layer manifests itself by a double contour. By an oblique illumination the inner contour, representing the place of separation of the membraneous layer from the protoplasm, is rendered darker and more distinct.

This phenomenon, frequently observed on fresh coloured blood-corpuscles of the Frog, teaches us that, under certain conditions still unknown, a separation of the protoplasm from its membraneous layer may occur, and extend over a greater or smaller space. Now, if such a separation, accompanied by a simultaneous contraction of the protoplasm upon the nucleus, occurs in a number of places, representing regular intervals between a number of small points, at which the union of the protoplasm with its membraneous layer remains undisturbed, that peculiar appearance or star-like form of the blood-corpuscle is produced which has given rise to those theories concerning the structure of these bodies, spoken of before. Such forms are said to be specially obtained in the blood of Amphibia by the aid of water, or by a 2 per cent. solution of boracic acid. Though I have not succeeded in producing these forms by these means, I have produced them by the action of a very weak solution of chromic acid. But having, moreover, observed them naturally to occur in the *fresh* blood of the Frog, and also in that of a young Amphibia (Fig. 44), I have taken the view that the reagent plays only a subordinate part, as far as the production of these peculiar forms of blood-corpuscles is concerned; they rather depend on a peculiar condition of the protoplasm, favouring the separation from the membraneous layer. And, indeed, the case appears to me so plain, that I can hardly conceive how it ever could have become a puzzle, even to some eminent histologists. For if we only imagine such a condition to exist throughout, where the protoplasm insensibly blends with the membraneous layer, and that at the same time a contraction of the protoplasm should take place, an entire separation of these two parts of the blood-corpuscle must evidently be the result. The protoplasm in such a case retracts upon the nucleus, which it completely surrounds, while the membraneous layer appears isolated, manifesting itself by a delicate double contour. And again, if the same process should take place without entirely separating the protoplasm from the membraneous layer, but leaving at certain small points a union between the two parts, the result must be the production of a number of filamentary processes, arising from the main bulk of the protoplasm and passing to those points of the membraneous layer. Of course, these processes are drawn out during the contraction of the protoplasm (Fig. 44). In the fresh blood-corpuscles the contraction of the protoplasm must be attributed to natural though at the present time unknown causes. In those instances where the peculiar form of blood-corpuscles is produced by means of certain reagents, I suppose that a condition favouring the separation of the protoplasm from the membraneous layer pre-exists, but that the contraction of the former is called forth by the action of the particular reagent used. A representation of these star-like forms of blood-corpuscles artificially produced, and on a large scale, will be found in fig. 73, accompanying Rollett's article "On the Blood," in Stricker's 'Handbuch der Lehre von den Geweben, &c.' The double contour, representing the membraneous layer, seems to have been overlooked in this drawing. Fig. 57 of my own drawings represents these forms on a smaller scale, produced on the coloured blood-corpuscles of the Tree-frog (Hyla) by the action of a very weak solution of chromic acid. At *a* the protoplasm has contracted in the form of a star, while the isolated membraneous layer manifests itself by a delicate double contour; at *b* the processes of the protoplasm also have, by a continued action of the reagent, become separated from the membraneous layer, and retracted into the general mass of the protoplasm, covering the nucleus.

Among the fresh blood-corpuscles of the Frog, still other forms than those just discussed are produced by the contraction of the protoplasm, and not unfrequently met with in examining specimens of blood. Thus, blood-corpuscles with irregular sharp ridges or spines, projecting from their surface (Fig. 50), will be observed. It must be obvious to the observer that these forms resemble those thorn-apple forms which are of quite common occurrence in human blood.

When the coloured blood-corpuscles of the Frog are treated with water, the same phenomena are observed as have been described in connection with the blood-corpuscles of the Amphiuma. Their colouring matter gradually disappears, until they are rendered entirely colourless. But their outlines do not become invisible; on the contrary, they appear now in the form of a delicate double contour (Fig. 51, *a* and *b*), representing the membraneous layer of the blood-corpuscle. In some instances the outlines appear wavy or crenated; of the probable cause of this appearance I have attempted to give an explanation in connection with the blood-corpuscle of the Amphiuma. As in the case of the latter, the granules contained in the nucleus are also dissolved by the action of water, while the whole body expands. Treated with a very weak solution of chromic acid after having been acted on by water, the delicate contour of the blood-corpuscle, as well as that of its nucleus, appears at once darker (Fig. 52), while a few granules reappear in the latter.

When the blood-corpuscles of the Frog are exposed to the action of the vapour of acetic acid for about one minute, the protoplasm is observed to coagulate in the form of small granules, while the membraneous layer, represented by its double contour, remains unaltered. At the same time, the former contracts, leaving a clear space between itself and the nucleus (Fig. 53). Treated with the liquid acetic acid in a diluted form, the blood-corpuscles are rendered entirely colourless, but bordered by a delicate double contour; while the nucleus becomes dark bordered.

Subjected to the action of chloroform vapour for several minutes, these blood-corpuscles are discoloured, and their outlines rendered very faint, almost invisible. When in this condition they are treated with a very weak solution of chromic acid, their outlines will reappear in the form of distinct dark double contours, together with numerous granules distributed throughout the interior (Fig. 54, *a*). In some instances (*b* and *c*) a number of these granules are observed to be arranged in lines, radiating from the nucleus toward the periphery. Sometimes the blood-corpuscle assumes the form of a dumb-bell (*d*).

The effect produced on the blood-corpuscles of the Frog by the action of a strong solution of hydrated chloral, differs somewhat from that observed on these bodies in the blood of the Amphiuma.

The first changes consist in the formation of a number of distinct wrinkles on the surface of the corpuscle (Fig. 55, *a*), which, however, disappear again with the continued action of the reagent; at the same time numerous granules appear in the protoplasm (*b*), while the membraneous layer manifests itself by the usual double contour. An interesting specimen with which I met is represented at *c*; here the membraneous layer of the blood-corpuscle has burst, and the homogeneous protoplasm is seen to escape from the interior. Next, if the action of the reagent continues, the granules in the protoplasm disappear again, the corpuscle appearing perfectly clear (*d*); and finally, even the membraneous layer is dissolved, so that nothing remains but the nucleus.

The Coloured Blood-corpuscles of the Tree-frog (*Hyla*), represented at Fig. 56, *a* and *b*, resemble in every respect those of *Rana pipiens*, except in size; for they only measure about $\frac{22}{1000}$ mm. in length. The frequent occurrence of blood-corpuscles with certain portions of their bodies wanting, and appearing as if these had been removed by means of a sharp instrument (Fig. 56, *c*), has already been mentioned in the beginning of this article, with an attempt to explain this phenomenon. The changes observed to take place in these corpuscles by the action of a weak solution of chromic acid, as represented in Fig. 57, *a*, *b*, and *c*, have also been referred to before.*

The Coloured Blood-corpuscles of Man.—The investigation of these blood-corpuscles, together with those of all other Mammalia, is, in consequence of their small size, rendered much more difficult than that of the large blood-corpuscles met with in the

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* I take the opportunity of mentioning the presence of an Infusorium in the blood of the Tree-frog, which I observed during three successive years in every individual of the species examined. Mr. E. Ray Lankester described a similar animal, in the 'Quarterly Journal of Microscopical Science' for 1871, which he had discovered in the blood of *Rana esculenta*, and which he named *Undulina ranarum*. As I am not sure of the exact identity of the animals observed, I do not hesitate to allude to the subject in this place, if only for the purpose of corroborating the fact previously discovered. The Infusorium which I observed (Fig. 58) belongs to the Flagellata, as the long whip or flagellum with which it is provided indicates, and is found in constant motion, alternately coiling its body in one or the other direction into a spiral form. On the convex side of the coil a number of teeth-like processes are observed in constant and rapid motion, giving to this part of the body the appearance of a cog-wheel turning in one direction. As the animal is never seen at rest, but alternately coiling and uncoiling its body, the examination of this part of its locomotive apparatus is rendered very difficult. The motion appears not to be owing to the vibration of cilia; it rather seems to be produced by minute transverse folds successively arising in one direction in the integument of the creature, in the same manner as waves do in the water when a heavy body falls into it. With the object of rendering the motions of the animal slower for observation, I have treated the preparation with several reagents without any advantage; for the animal, in dying, rolls itself up into a confused mass. These Infusoria exist in considerable numbers in the blood of the Tree-frog; a small drop, of the size of a pin's head, when spread into a thin layer under the microscope, may be found to contain about a dozen individuals or more.

animals of the remaining classes of the Vertebrata. While the latter, to which those of the Amphiuma and the Frog, discussed in the preceding pages, belong, are distinguished by their large size, by their oval and bi-convex form, and moreover by enclosing a conspicuous nucleus, giving them the character of a complete organic cell, the blood-corpuscles of the Mammalia are more minute in their dimensions, round and bi-concave in form, and embracing no nucleus, they rather represent an organic cell of a more simple construction. Accessible at all times, the blood-corpuscles of Man, especially, have always been a favourite object for microscopic examination; and owing to the important part which they play in the organism of Man, their nature has been studied and discussed by anatomists and physiologists over and over again. For this reason I should forbear from making any further remarks on the structure and nature of these bodies, if I were not conscious of the fact that, notwithstanding the numerous investigations already made, the subject has not in all cases been fairly dealt with, and is therefore not yet exhausted. On the contrary, in order to finally settle the question whether the coloured blood-corpuscle of Man possesses or not an enveloping membrane, a re-examination of the subject becomes necessary, particularly by those histologists who deny the existence of such a membrane in any form. The coloured blood-corpuscle of Man shows a double contour under various circumstances and conditions, indicating the existence, if not of an enveloping membrane, at least of a membraneous layer on its surface; and anyone who chooses to examine these bodies in the manner to be described hereafter, will be convinced of this fact.

It is an admitted fact that the coloured blood-corpuscles of Man represent minute bi-concave disks (Fig. 59, *a* and *b*) with rounded margins, and of a diameter of about $\frac{1}{100}$ mm. They are very delicate in substance, and being elastic and flexible in an unusually high degree, are enabled to resume always their original form, when distorted by mechanical causes. In fact, the momentary changes of form, which they are constantly undergoing when floating in the liquor sanguinis, are owing to the great delicacy and elasticity of their protoplasm. In examining them under the microscope with a sufficient amplification, we observe that the most feeble current arising in the liquid in which they float, disturbs their form, either directly or by causing individual corpuscles to touch each other in passing, or also by calling forth a mutual pressure in a greater number of blood-corpuscles. When a coloured blood-corpuscle of Man is examined in the state of rest from the front, its outline appears perfectly round. Being put in the proper focus, so that its outlines appear the most distinct, its centre, to the extent of about one-third of the whole diameter, appears light. Proceeding toward the periphery of the corpuscle, a slight shade is seen to arise from the light centre, which, after somewhat increasing in depth, is gradually lost, to be followed by the high light, representing the convexity of the margin (Fig. 59, *a*). This variation of light and shade is of course caused by the form of the corpuscle. The convex margin appears most illuminated at the highest part of the convexity, where the rays of light passing through it undergo no, or very little, refraction, while more or less shade must appear, by virtue of the refraction of light, at that part of the surface which inclines toward the centre, and forming a part of the concavity; the centre finally being the thinnest portion of the corpuscle and very nearly flat, must, from the absence of almost any refraction, appear light. Owing to the rounded margin of the blood-corpuscle, its very outlines do not appear distinctly and sharply defined; on the contrary, a delicate shade is observed at the very edge, which soon disappears in the high light of the convexity. No trace of the existence of a membrane or a membraneous layer can be discovered in the fresh blood-corpuscle of Man. When brought into the exact focus, it appears encircled by a distinct narrow ring of a pinkish tint, much lighter than the rest of the surrounding liquor sanguinis; this phenomenon is probably owing to the corpuscle refracting the light toward its less refractive liquid medium. The appearance of the coloured blood-corpuscle of Man in exact profile is peculiar, and corresponds not to the bi-concave form, in which it is so often erroneously represented. Recollecting that its body represents a minute round plate or disk, the peripheral portion of which, besides being convex and rounded at its border, is twice as thick as the central, which is concave, and further, that it is perfectly symmetrical at all points, it becomes evident that the outlines of its profile must be represented by two *straight* and *parallel* lines, connected at their extremities by two semicircular ones; and accordingly the side view of the corpuscle could not reveal the concavity of the central portion. But if a vertical section were made through the centre of the corpuscle, the outlines of the cut surface would be represented by two slightly curved lines, which directing their convexity toward each other, are connected by semicircular lines, showing not only the bi-concave form of the central, but also the convex and rounded form of the peripheral portion of the body.

The contour of the coloured blood-corpuscle in profile, though in reality corresponding to the above description, may nevertheless appear differently when the object is carelessly examined, and instead of being represented by two straight and parallel lines, connected by semicircular ones, its sides may appear bi-concave, resembling the outlines of a section through the centre, as before described. The cause of this optical illusion must be sought in the great transparency and refractive power of the protoplasm, of which the blood-corpuscle consists, and it is this circumstance which has caused those erroneous representations of the profile of this body, heretofore alluded to.

In examining, therefore, a coloured blood-corpuscle in exact profile, the contour, which first strikes our eye, is a dark one, resembling in shape that of a section of the corpuscle (Fig. 59, *b*), and showing the concavities of the two surfaces. A closer examination, however, will reveal two distinct straight lines, being the true outlines of the sides of the profile, and extending on each side from one convexity of the dark contour to the other, as may be seen in examining the drawing. With the least movement made by the blood-corpuscle, the view of the exact profile will be lost, and a portion of the front surface of the object will be presented. At and near the median line the object appears very light, this being the part representing the middle of the convex margin, where the rays of light, after having passed through the corpuscle, undergo the least refraction, and where, moreover, all rays refracted at the convex surface, meet in the same focus. Thus, the true contour of the profile of the blood-corpuscle in question, in reality represented by two straight and parallel lines, connected by two semicircular ones, nevertheless includes another contour, representing the section of the object. This singular appearance, owing to the transparency and the great refracting power of the substance of the blood-corpuscle, as well as to its peculiar form, will be readily understood by the reader.

The true profile of the blood-corpuscle is most favourably seen when this body is floating in the liquor sanguinis, and turning slowly around its long or horizontal axis. Owing to the great delicacy of its substance, the corpuscle is very apt to bend upon itself in various ways, from the slightest resistance it meets in its course when floating in this liquid; and it is for this reason that a good view of the profile is not always obtained. A correct view can only be obtained when the corpuscle remains stationary for a few seconds, with the full profile turned towards the eye of the observer. The slightest motion, as mentioned before, will present a portion of one or the other front surface and interrupt the view.

The colour of a single blood-corpuscle, when seen under the microscope, is not a yellow, as has been stated sometimes, but more of a light greenish tint. It is only when a number of corpuscles are collected into a small mass or group, and resting upon each other, that the original greenish tint merges into a yellow. With the increase of the thickness of the mass, the yellow becomes darker, and finally passes into the scarlet red, as seen in a drop of blood.

Soon after a small drop of human blood has been put on the glass slide and covered with the plate of thin glass, a number of blood-corpuscles are observed to change in various manners, and in a slighter or greater degree, their original form. In some instances the convex peripheral portion of the corpuscle appears to shrink in thickness at one point, while the rest of it swells and gains in diameter, so that the whole body assumes a wedge-like form (Fig. 60, *a* and *f*). In other instances the blood-corpuscle assumes the form of a shallow basin, an appearance which is very probably caused by a contraction of the convex border of only *one* surface, by which process the concavity on this surface increases in depth, while the other surface is rendered convex instead of concave. If the contraction continues, the corpuscle assumes the form of a deep cup. Whether during this process the central portion increases in thickness, while the convex periphery is rendered thinner by the contraction, is difficult to determine; but that the contraction takes place only on *one* surface of the convex margin is obvious; for if it occurred throughout the whole margin, the corpuscle would not become cup-shaped, but would preserve its original form of a disk, though its central portion might gain in thickness, while the concavities of its surfaces would decrease in depth or entirely disappear. Sometimes the convexity of these cup-shaped forms terminates in a conical protuberance, as seen in Fig. 60, *e*. There is another very singular form observed, difficult to describe, but resembling in some respects the wedge-like form, with the exception that the narrow portion of the wedge, instead of being straight, assumes here the form of a Y, showing that the body must be three-sided (Fig. 60, *g*).

Intermediate forms, similar to those above described, are observed (Fig. 60, *b*, *c*, and *d*); but it will be noticed that in all these instances it is only a portion of the protoplasm of the blood-corpuscle which is contracting, while the rest is expanding in compensation of the contraction. There are, however, other changes occurring in the form of the corpuscles, owing to a contraction of the protoplasm throughout the whole body, and accompanied by a considerable diminution in size. As the result of such a contraction, we may regard those familiar forms of blood-corpuscles, generally compared to a mulberry or a thorn-apple. These, when occurring on the blood-corpuscles of fresh blood, and without the action of a reagent, have generally been attributed to the evaporation of the liquor sanguinis. With the increase of the density of this liquid, namely, an exosmotic current from the blood-corpuscles is supposed to be induced, causing shrivelling of the corpuscles. If this view were correct, those corpuscles nearest to the edge of the drop of blood should first undergo the changes in question. But this is not the case; on the contrary, single mulberry or thorn-apple shaped blood-corpuscles are observed among the mass of unaltered ones in the centre of the preparation, immediately or soon after the blood is placed on the slide. Soon after, other individual corpuscles are seen to assume these forms, the number increasing with the time, until finally whole groups or the entire mass may undergo this change. In other instances, considerable portions of the blood-corpuscles of the preparation may, soon after the blood is put upon the slide, contract at once, and assume the thorn-apple form, appearing almost as if affected by a general contagion. The thorn-apple form may even be produced by the action of water, as I have observed. The form of the blood-corpuscle, when gradually and slowly undergoing these changes, seems to pass through several phases. The first deviation from the original form observed, consists in minute elevations or protuberances, arising from the surface of the corpuscle at its rounded margin, thence, while increasing in number, extending over the entire corpuscle. Next, the protuberances, at first of a conical form, become gradually smaller in diameter at their base, while their points or summits enlarge to assume the form of a knob, resembling a granule. It is at this stage of the change that the form of the blood-corpuscle has been compared to that of a mulberry. As the change continues, the globular projections become thinner, until finally they are transformed into minute, sharp spinous processes. In this state the blood-corpuscle resembles a thorn-apple. But it is not necessary that, when the change of form has once set in, it should pass through all the stages to the ultimate thorn-apple form; on the contrary, the contraction may cease at any stage of the process, or even cause at once the mulberry or thorn-apple form. Very little alteration in the general form of the corpuscle is observed to take place by this process; it is not rendered spherical, as might be supposed, but represents still a disk, though the concavities may have disappeared from its surfaces, or even be converted into convexities.

In the beginning of this paper, when describing the changes observed to occur in the form of the fresh giant blood-corpuscles of *Amphiuma tridactylum*, I related an instance (Fig. 11) in which I distinctly observed a spontaneous expansion and contraction occurring in one of these bodies. This was the only case of spontaneous motion I ever met with in the blood of the Amphibia, though in the coloured blood-corpuscles of Man I had witnessed this phenomenon as early as in the summer of 1871. In examining a specimen of human blood, and whilst my attention was directed to the coloured corpuscles as they were carried along by a moderate current of the liquor sanguinis under the covering glass, I noticed on some of them the projection and immediate withdrawal of minute, conical, thorn-like processes (Fig. 61, *a*), whenever one blood-corpuscle came into the vicinity of another, without, however, actual contact. It seemed almost as if one corpuscle were attracting or drawing out the thorn-like process from the surface of the other. In other instances, however, I observed the shooting forth and quick withdrawal of these processes from the margins of corpuscles not in close vicinity to others (Fig. 61, *b*, *c*, and *d*). As these processes appeared at the marginal surfaces of the blood-corpuscles, before the latter had come in contact with other of their fellows, I naturally regarded the phenomenon as one of spontaneous motion, manifested by the coloured blood-corpuscle. But as in most instances the phenomenon was observed in corpuscles passing near each other, I was inclined to attribute it to a certain power of mutual attraction, residing under certain conditions in the coloured blood-corpuscle. Having taken the precaution of slightly warming the glass slide before putting the blood, quickly taken from the vessels of the skin of a vigorous young man, upon it, and the temperature of the surrounding air being 96° F., or even more at the time, I also considered a certain amount of heat, at least 98° F., as essential to the manifestation of the phenomenon. This view, however, proved to be erroneous, as I shall show directly. Although I have witnessed this phenomenon on blood-corpuscles when in a state of rest, it nevertheless is more frequently observed on blood-corpuscles in motion, as when they are carried along by a current, arising in the specimen under the covering glass, and resembling in character the current of the blood in the capillary vessels. With this view the drop of blood should be thinly spread upon the glass slide, and quickly covered with the thin plate of glass. While the blood-corpuscle is projecting the thorn-like process, its body elongates, resembling a uni-polar cell, but with the withdrawal of the process, generally assumes its original round form; bi-polar or lemon-shaped corpuscles are also frequently met with in specimens of human blood. The same process is also observed when the margins of two corpuscles actually touch each other very slightly, and then slowly separate again. While separating, the thorn-like processes will be drawn out at the exact place of contact, and either remain permanent, or disappear again after the separation has taken place.

That the normal heat of the human blood is not essential to the manifestation of spontaneous motion in the coloured corpuscles, I discovered during the past winter, while repeating my examinations of the structure of these bodies. I then witnessed the phenomenon above described, without having warmed the glass slide and covering glass, and at the temperature of a moderately warmed room. However, I observed a coloured corpuscle of a constricted form, similar to a figure of eight, slowly expanding, and finally resuming its original round form (Fig. 61, *e* and *f*).

From this we may conclude that the coloured blood-corpuscle of Man possesses not only a certain inherent power of contracting its body, but also of resuming its original form by a subsequent expansion, a characteristic property of the living protoplasm, enabling the coloured corpuscle to manifest spontaneous motions, though not to so great an extent as is seen in the colourless. And, furthermore, keeping in mind this inherent property, a part of the difficulty hitherto encountered in tracing those various spontaneous changes occurring in the form of these bodies to their cause, will be removed.

Nevertheless, as these changes are not only observed to occur in different localities of the same preparation of blood, and under different circumstances, but moreover are observed to occur in a greater or lesser degree in different specimens of blood, when taken at different times from the same individual, much doubt will still remain as to the true cause of the phenomenon, and the conditions under which it is manifested. The question therefore arises: Do these changes of form indicate progression and development and a high degree of vitality residing in those blood-corpuscles exhibiting them; or are they resulting from a loss of vitality, and therefore manifestations of retrogression and decay? In the one case, then, they would probably occur on the young, in the other on the old corpuscle.

Without pretending to solve this difficult question, I shall venture a few remarks relating to it. If, namely, the changes affecting the form of the coloured blood-corpuscle, and evidently caused by a contraction of its protoplasm, were indicative of a higher degree of vitality or molecular action, we should meet with a greater number of mulberry and thorn-apple shaped, or otherwise deformed corpuscles in the fresh blood. But as, on the contrary, the number of these forms is comparatively small, immediately after the blood is removed from the living tissues, and, moreover, increases sometimes quite rapidly in proportion to the length of time intervening, it appears more probable that these changes of form indicate retrogression, and we may be justified in regarding them as the result of the last vital action manifested by the blood-corpuscle, and portending its death.

In proof of the absence of an enveloping membrane in the coloured blood-corpuscles of the Amphibia as well as of Man, it has been asserted that they will run into and fuse with each other by mutual pressure. It appears to me strange that such a coarse error should ever have been committed; for these bodies never run into each other unless they are forcibly crushed into a structureless mass. Even in such a manner it is difficult to destroy their individuality, as I shall presently show. It is true that when a drop of blood is spread upon a glass slide, the coloured corpuscles will by mutual pressure become more or less distorted in shape in those places where they are pressed upon by the weight of the covering glass. The amount of pressure, and also the more or less crowded condition of the corpuscles, will determine the degree of deviation from the original form. Thus, when a single corpuscle is pressed upon, it will simply enlarge in its horizontal diameter, while it is rendered thinner and flat. In the case of a group, mutual pressure will come into play, causing the corpuscles to assume more elongated or otherwise irregular forms; or, as it frequently happens, when the corpuscles are arranged in a single layer, and mutual pressure is exerted upon their margins, they will assume a hexagonal form, similar to the cells of a pavement epithelium. Finally, when the pressure rests upon a whole mass of corpuscles, they may even assume the form of spindles. At the same time, the hæmoglobin is seen to escape from the blood-corpuscles into the surrounding liquor sanguinis. I have observed that in cases where the pressure rests upon a mass of corpuscles forming the edge of the preparation, their colour appears of a dirty brick-red, and darker than in other localities. The cause of this appearance I am unable to determine; perhaps it is owing to some process of oxidation going on at the margin of the drop.

If now a drop of water is applied to the preparation, and its effect upon the mass of distorted blood-corpuscles carefully watched, it will be seen that the greater part of them, though fused into each other, as they may appear, will gradually separate, and resume their original shape. If the pressure be kept up for a long time, a portion of the corpuscles, though separating, may not entirely resume the round form, but remain more or less distorted.

When a very small portion of human blood is spread upon a glass slide, and, after being covered with the thin plate of glass, a drop of water be added to the preparation, it will dilute the liquor sanguinis and induce an immediate escape of the hæmoglobin from the blood-corpuscles, rendering the liquid in the vicinity of the latter, according to their number, more or less turbid. At the same time the blood-corpuscles will be set in motion, and float away into the clearer parts of the liquid. Continuing to part with their colouring matter, they are gradually rendered pale, and finally appear as mere shadows. If now a portion of the liquid is removed by the careful application of a minute point of a piece of blotting-paper, and its place filled by a drop of clear water, the shadow-like blood-corpuscles will appear bordered by a delicate double contour (Fig. 62, *a*). The central portion of the corpuscle, encircled by the inner contour, appears now of the colour of the field, while the margin, included by the two contours, appears lighter when put in the exact focus. Of course, only a first-class objective of sufficient amplification, say one-tenth of an inch, or even higher, should be employed for such an examination.

Now the question arises: Does the inner contour represent that delicate shade, which I described on the fresh unaltered blood-corpuscle as representing the inclination, passing from its thick convex marginal to its thin and concave central portion; or is it in reality the inner contour of an existing membraneous layer, made visible by the solution of the protoplasm within it, as in the case of those large nucleated coloured blood-corpuscles of the Amphibia? Let us try to solve this question. A close examination of the front surface of one of these blood-corpuscles, affected by the action of the water, will reveal that the diameter of the central portion of the corpuscle has increased, while that of the peripheral portion, representing its convexity, appears much narrower than in the fresh specimen. From this we may judge that there must have been some loss of substance in the interior of the blood-corpuscle, causing it to collapse in thickness. In other words, the protoplasm, with the exception of a thin stratum or layer forming the surface of the corpuscle, was dissolved by the action of the water, giving to the whole the character of a cell. Thus the changes brought about by the action of water in the non-nucleated blood-corpuscles of Man are similar to those observed under the same conditions in the large nucleated corpuscles of the Amphibia. No true cell-membrane can be discovered in their normal condition; while in either case a delicate stratum seems to exist at the surface of the corpuscle, which, being denser in its nature than the rest of the protoplasm, resists longer the solvent action of the water, and in consequence manifests itself in the form of a delicate double contour. In the human blood-corpuscle this membraneous layer, as we have called it before, must be exceedingly delicate, as no trace of it can be discovered on the fresh unaltered specimen. It is probable, however, that its invisibility in the fresh condition is owing to the circumstance of the peripheral portion or margin of the human blood-corpuscle being perfectly rounded, while the margin of the blood-corpuscle of the Amphibia is almost flat, and proportionately thinner, in consequence of the bi-convexity of the whole disk.

But the fact that a cavity is produced in the interior of the blood-corpuscle by the action of water, is rendered still more apparent when a specimen is examined in its exact profile, as may be seen in Fig. 62, *b*, where the delicate median line represents the cavity. This can only be done while the corpuscle is floating in the water, and slowly turning around its horizontal axis. When the corpuscles, after being altered by the action of water, are treated with a weak solution of chromic acid, the double contour appears still more distinct.

The blood-corpuscles of Man do not swell or assume a spherical form (as I myself several years ago erroneously believed) by the action of water; but, on the contrary, with the exception of a very slight diminution in size, they preserve the exact form, whether normal or distorted, which they possessed before the application of the water. Nevertheless, if the water be applied immediately after the various changes of form have taken place, they resume their original shape, as I have observed.

The presence of a delicate membraneous layer may be furthermore demonstrated by a simple experiment on the fresh blood-corpuscles, and without the assistance of any reagent. I cannot forbear to recommend this experiment, particularly to those histologists who deny the existence of this layer, in order to convince them of their error. It is as follows:—A very small drop of human blood, about the size of a small pin's head, is taken and placed upon the glass slide. After being covered with a *small* round covering glass, this is firmly pressed down upon the blood by means of the point of a forceps, with the object of compressing or crushing the blood-corpuscles as far as possible. For this reason, the point of the instrument may be passed over the covering glass, for the purpose of applying the pressure to every part of the blood; or the blood may be rubbed between the two glasses until they adhere to each other. A subsequent microscopical examination will show that it is not an easy matter to crush these bodies into a homogeneous mass, though they may in some places, where they formed small masses, have apparently run into each other. In directing our attention to single individuals, we find that they have considerably increased in their dimensions by having been pressed perfectly flat. Every trace of their central concavities and peripheral convexities, indicated in their normal condition by their light centres and by their bright margins, has disappeared; their bodies are uniform in colour or shaded throughout, with the exception of a light greenish border, similar or even more distinct than that seen on the coloured blood-corpuscles of the Amphiuma or Frog. On some of them clear streaks, representing fissures, caused by a rupture of the membraneous layer are observed. Those blood-corpuscles which had assumed the mulberry or thorn-apple form before the pressure was applied, also will be found pressed perfectly flat, with their dimensions increased and their margins crenated. The same light greenish border, mentioned before, will also characterize in these instances the margins of the blood-corpuscles. Some corpuscles have preserved their form of a circle, while the outlines of others appear more or less irregular, as kidney-shaped, ellipsoidal, spindle-formed, &c., in accordance with the form which they possessed before the application of the pressure; or when pressed into a mass, according to the degree of the mutual pressure exerted upon each other. If now a group or small mass of blood-corpuscles in the preparation is carefully examined with a first-class objective of sufficient amplification, it will be found that they have not run into each other, but that, on the contrary, the outlines of almost every individual may be discerned, however distorted they may be.

As in this experiment the blood-corpuscles are pressed completely flat, they represent minute plates with level surfaces, through which the rays of light pass without undergoing much or any refraction, except in places where a difference in the properties of their substance might exist. But, as the membraneous layer is probably somewhat differentiated from the rest of the body, it is seen at the margin of the blood-corpuscle in the form of a light greenish border. By applying a drop of water to the preparation before it has become dry, the blood-corpuscles are gradually rendered pale and faint; and their greenish borders will now appear in the form of distinct delicate double contours, as described before. In proportion to the amount of pressure previously sustained, they will retain their dimensions and their flatness; and in those places where they were crowded before the application of pressure, whether mutual or by the covering glass, and in consequence much distorted in shape, they will be seen separating from each other as the water takes effect, and floating away, presenting the same appearances as the others described.

In the course of my investigations into the structure of the coloured blood-corpuscles of Man, I also studied the effect of various reagents, such as chloroform, acetic, nitric, and carbolic acids, alcohol, as well as solutions of hydrate of chloral, boracic and chromic acids, &c., either in the gaseous or liquid form, upon these bodies. The changes observed to take place on these corpuscles by the action of these agents are, though not in every instance exactly alike, yet similar to those we have seen to occur on the blood-corpuscles of the Amphiuma or the Frog; they mainly consist in the escape or destruction of the hæmoglobin, contraction or coagulation of the protoplasm, change of form, &c. As I have described them before in connection with the blood-corpuscles of these Amphibia, they require no further remarks for our special purpose, except that they all appear to corroborate my view of the simplicity of the structure of the non-nucleated coloured blood-corpuscle, as well as of that of the nucleated.

In concluding this treatise on the structure of the coloured blood-corpuscles, I have only to add that I still believe a part of their function to be secretory. In accordance with this view I regard them as true glandular cells, which, independent of the part they may act in the transfer of ozone, are also engaged in appropriating certain materials from the plasma of the blood, in order to transform them into other bodies by virtue of their secretory power, and to finally return them to that fluid in the special condition required for the subservience of other purposes, such as the preservation of the normal constitution of the blood, as well as the nutrition of the various tissues.

Changes in the substance and form of the coloured blood-corpuscles of Man, similar to those above described, and which may be detected by the aid of the microscope, occur in various pathological conditions of the system. Although some attempts have been made by several pathologists to study these changes, no definite results have to my knowledge hitherto been obtained. The cause of this seeming failure, however, evidently depends on the difficulty attending the investigation of this subject, and I entertain no doubt as to the final success of these studies, if conscientiously and steadily pursued. For a number of years I have occasionally directed my attention to this subject, and have become convinced that changes in the form and character of the coloured blood-corpuscles of Man, which may be detected by microscopical examination, do occur in pathological states of the system; but as my observations were confined to only a few diseases, as yellow fever and rheumatism, and were not made systematically, I shall forbear entering upon this subject at present. After I shall have accumulated additional facts to those already obtained, and on a more extended scale, I hope to present them in proper form to the profession.

II.—*On the Present Condition of Microscopy in England.*

By Frank Crisp, LL.B., B.A., Sec. R.M.S.

(*Read before the* Royal Microscopical Society, *April* 3, 1878.)

My object this evening (writing throughout in the spirit of the Publican and not of the Pharisee) is to call attention to what I think is an indisputable fact, that in recent years no substantial progress has been made in this country either in the knowledge of the theoretical principles of the microscope itself, or in the systematic investigation of microscopical phenomena.

The microscope has, in fact, come to be regarded merely as the tool of the naturalist and the histologist; and notwithstanding the objects for which this Society was established,* it may, I think, be truly said that out of the entire scientific world there is probably no body of men who devote so little real attention to the principles that lie at the root of that branch of science of which they are disciples, as do the English microscopists.

As a particular instance, I may refer to the apathy that has been shown in regard to the researches of Professor Abbe on the theory of the microscope,—researches undoubtedly as important as any that can be found in the whole of its history, and rivalling even the discovery of achromatism, or that of Lister on aplanatic foci. It is, I think, not a little humiliating that such a discovery —in one aspect so simple—should not have originated in this country, we being the first, and for many years the only, nation to maintain a "Microscopical" Society.

Whatever may be the cause of such apathy, it is evident that it cannot be attributed to any deficiency in the power of perseverance; for when we enter upon the discussion of a question, say of angular aperture, we do not rest content until a point has been reached which renders it impossible for anyone to say that the subject has not been exhausted to the very last limits.

For this the condition of our literature is in part answerable. Recall the contents of the generality of modern English treatises on the microscope, and what do we find? Out of a given number of pages, a very small portion only is devoted to the optical prin-

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* The statement of the "Objects of the Society," prefixed to the Charter and Bye-laws, sets forth that "the Society was established *for the promotion and diffusion of improvements in the optical and mechanical construction, and in the mode of application, of the microscope*:—

"*For the communication and discussion of observations and discoveries tending to such improvements or relating to subjects of microscopical observation*:—

"For the exhibition of new or interesting microscopical objects and preparations, and for the formation of an arranged collection of such objects:—

"*For affording the opportunity and means of submitting difficult and obscure microscopical phenomena to the test of instruments of different powers and constructions*:—

"For the establishment of a library of standard microscopical works."

ciples of the microscope and to microscopical phenomena (about as much as is to be found prefaced to foreign books on histology or botany that do not pretend to be treatises "on the microscope" at all), and what is given is in the most elementary form that can be conceived. The remainder of the book is avowedly a condensed summary of the whole range of subjects belonging to natural history—a small natural history cyclopædia.*

If we compare our books with those of some other countries, in particular Germany and Holland, the conviction must be forced upon us that we in England have not in modern times kept pace with the progress that has been made elsewhere. I am not venturing to reflect in any way upon our authors, the blame must rest upon ourselves and not upon them. The supply is necessarily regulated by the demand—if there is no demand there can hardly be expected to be any supply, so that any improvement must originate from ourselves.

The principal reasons, as I conceive, for this state of things are these.

In the first place, a feeling has gained ground amongst us that the only proper field for the microscopist is to be found in the investigation of one or other of the many branches of natural science that require the aid of the microscope, and hence the theory of the microscope itself and of microscopical phenomena is regarded as altogether puerile and unworthy of the attention of the true microscopist.

For myself, I may freely confess that (erring, no doubt, in the opposite extreme) I take a comparatively small interest in the subjects to which the microscope is applied, and that I am almost inclined to look on the term "microscopist" as not being properly applicable to those who are engaged in the study of natural history, even although it may be essentially by means of the microscope—in fact, that as it has been said "the proper study of mankind is man," so the proper study of the microscopist is the microscope.

It has been objected, and no doubt will be objected again, to this view, that it is fallacious, in so far as it exalts to an end that which ought only to be looked upon as the means to the end—that the microscope (as I was recently told) can be properly regarded as nothing more than the ladder by which we climb to a point from which a better prospect may be obtained, and that it is a waste of time in such a case to devote attention to the ladder rather than to the prospect.

Such an argument—one that exalts the applications of a science at the expense of the investigation of its theoretical principles, on

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* This does not, of course, apply to books that do not pretend to describe the microscope, but to furnish directions for its use.

the ground of the greater practical value of the one over the other—is a strange one to be used by scientific men. It is the merest truism to say that the only sure way to advance any branch of knowledge is by undertaking a complete and exhaustive investigation of the theoretical principles on which it is based. All the practical inventions ever made have depended for their discovery on the previous investigation of mere theories, by men who pursued knowledge for its own sake alone, and without stimulus from any notions of practical utility.

As an old writer (Malthus) has put it:—"It surely would be most unwise to restrain inquiry conducted on just principles, even where the immediate practical utility of it is not visible. In every branch of natural philosophy how many are the inquiries necessary for their improvement and completion which, taken separately, do not appear to lead to any specifically advantageous purpose; how many useful inventions and how much valuable and improving knowledge would have been lost if a rational curiosity and a mere love of information had not generally been allowed to be a sufficient motive for the search after truth." *

If only the lowest view of the microscope is to be accepted, the improvement of the mere tool must necessarily have an important influence on the perfection of the work performed by its aid, so that the improvement of the microscope will directly further the aims of the naturalist.

Another reason which has also operated to produce the present condition of things is, that some kind of belief, more or less definite, has grown up, that we have arrived substantially at a state of perfection, or at the limits of the possible; that there being no further scope for improvement, the study of theoretical principles has become a matter entirely of antiquarian research.

I should not have thought that such a belief could be seriously held, had it not received the sanction of one of our high living authorities, who, whilst sufficiently cautious to guard himself against being supposed to assert the absolute impossibility of further improvement, yet, after speaking of the microscope as having "acquired the deserved reputation of being one of the most perfect instruments ever devised by art for the investigation of nature," ventures to say that "the statements of theorists as to what *may* be accomplished are so nearly equalled by what *has* been effected, that little room for improvement can be considered to remain until chemists furnish opticians with new varieties of glass whose refractive and dispersive powers shall be better suited to their requirements." †

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* 'Principles of Political Economy.' This point has also been well treated by Professor Tyndall in his concluding lecture on Light.

† Carpenter, 5th ed., 1875, p. 6.

This statement depends for its validity upon the assumption that the theorists have themselves arrived at the stage of perfection, an assumption which has no real foundation. I venture to think that there are few persons in the present day who would be found bold enough to assert that we have arrived at perfection in any branch of science, least of all in that of microscopy. Adopting the view of Sir John Herschel, "we are not to suppose that the field is in the slightest degree narrowed, or the chances in favour of fortunate discoveries at all decreased, by those which have already taken place; on the contrary, they have been incalculably extended. It is true that the ordinary phenomena which pass before our eyes have been minutely examined, and those more striking and obvious principles which occur to superficial observation have been noticed and embodied in our systems of science; but not to mention that by far the greater part of natural phenomena remains yet unexplained, every new discovery in science brings into view whole classes of facts which would never otherwise have fallen under our notice at all, and establishes relations which afford to the philosophic mind a constantly extending field of speculation, in ranging over which it is next to impossible that he should not encounter new and unexpected results. . . . In whatever state of knowledge we may conceive man to be placed, his progress towards a yet higher state need never fear a check, but must continue until the last existence of society." *

If perfection is ever to be assumed, one might fairly have assumed that the vast amount of research which has been bestowed upon the subject of electricity, the many minds that have for many years been engaged upon it, and the stimulus of the brilliant pecuniary and other rewards which have been earned, would have brought that branch of science, at any rate, to perfection; and yet it is only to-day that the Telephone has been discovered—an invention, not the least remarkable feature of which is its extreme simplicity.

Even, therefore, if the theoretical principles of microscopy had been apparently as well investigated and as well exhausted, we should still not be justified in "resting and being thankful"; but when, in fact, no such equivalent work has been done, I cannot be accused of any tendency to be over-sanguine if I think that the period of perfection in regard to the microscope is certainly yet before us.

The microscope, beyond all other instruments, has already suffered greatly from the belief that it could not be improved. So splendid a discoverer as Newton asserted that achromatism was "impossible," though the fact of the achromatism of the eye

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* 'Discourse on the Study of Natural Philosophy.'

was as ready to his hand as it was to that of Hall; and even after achromatism had been established, Biot (no mean authority) declared that it would be "impossible" to work achromatic object-glasses for the microscope on account of their diminutive size.

It is both amusing and instructive to take books written at different periods of the present century, and note how each writer in his turn expresses the conviction that now at last perfection has been reached. Thus Sir D. Brewster, in 1813, wrote that, "in the combination of single lenses to form the compound microscope, opticians have arrived at a great degree of perfection." In 1829, after the first achromatic object-glass had been successfully made, Dr. Goring wrote that "microscopes are now placed completely on a level with telescopes, and like them must remain stationary in their construction." Sir D. Brewster, later, wrote: "The ingenuity of philosophers and of artists has been nearly exhausted in devising the best forms of object-glasses and of eye-glasses for the compound microscope." What was written so lately as 1875 I have already referred to.

I believe that we are far from having arrived at the limits of the possible; but whether this view is accepted or not, I may, I think, assume that, however high may be the authority on which such a statement as that which I have referred to is made, there can be no necessity to spend any time in proving that much is still to be learnt—that we all agree in the definition given of the character of the true philosopher, "hoping all things not impossible, and believing all things not unreasonable," and "are ready to encourage rather than to suppress anything that can offer a prospect or a hope beyond the present obscure and unsatisfactory state."

What, in my view, is desirable is not that the Society should value less highly than they do now investigations in the various branches of natural science that can be made only by the aid of the microscope, nor that we should in the smallest degree diminish the appreciation which we have of those Fellows who bring the results of such investigations before us; but simply that *more* attention and encouragement than are given at present should be given by the Society collectively, and by the Fellows individually, to what I may call the subject of pure microscopy, which may be considered as standing in much the same relation to what is now accepted as "microscopy," as pure mathematics stands to applied mathematics (so called).

The optical principles of the microscope and its accessories form one branch, the other deals with the investigation (considered mainly as a problem of mathematics and physics) of the phenomena presented by objects viewed by means of the microscope, and the determination of their real properties, notwithstanding their deceptive visual appearances.

It would perhaps be only imitating the old quarrel of the logicians to discuss whether there can be any science of microscopy outside these limits; but if it be otherwise, the boundaries of the science must be as extensive as the world itself, the elephants and palms having as good a claim in that case to be considered "microscopic objects" as the rotifers and the diatoms.

I need not dwell on the first branch further than to point out that our text-books give the uninstructed reader the impression that the microscope stands in point of principle on no higher level than the telescope. This is far too low an estimate, and it would be truer to say that the microscope stands to the telescope at as great a relative distance as the chronometer stands to the sun-dial. Without having before them the means of comparison, it will, I know, be difficult, if not impossible, to convince the Fellows how much there is in this respect of which we know absolutely nothing: when the comparison has been made, the absurdity of the chapter in our books which professes to deal with "the optical principles of the microscope" will be fully appreciated. Whilst as M. Robin, the French histologist and microscopist, says, "it is absolutely necessary to be familiar with all that concerns dioptrics when one has to make use of an instrument whose invention has been inspired by the discoveries made in this part of physics," I do not know a book that even attempts to instruct the microscopist as to the course of the rays in passing through the ordinary objective of a compound microscope, or ventures upon anything beyond the barest mention of diffraction—the most common of all microscopical phenomena, and most intimately concerning not only the theory but the practical working of the microscope.

At the present time there is nothing extant which constitutes even a commencement of a systematic theoretical treatment of the subject of illumination, yet, being purely optical, it is obviously capable of being so treated, and great practical advantages would undoubtedly follow from the development of an exact theory on the subject. In nothing has the ingenuity of microscopists been more exercised than in the invention of novel modes of illumination for lined objects; but however clearly these various appliances may bring out particular appearances, there is good reason to believe that in the majority of cases they are illusions, originating in the character of the illumination employed, and that all possible methods of illumination may be reduced from the fifty or more kinds now existing to less than half a dozen at the most.

With regard to the second branch, the conditions under which microscopic vision takes place necessitate (at any rate, in our present stage of experience) a more or less laborious reasoning process before we can recognize what it is we really see, though long experience and habit have enabled us (apparently) to dispense with any such reasoning in the case of ordinary vision. The appreciation of this necessity has in modern times been a little lost sight of, and there has been too great a tendency to depend on mere sense, instead of on sense and reason combined, or, in other words, to merely *view the object* rather than to investigate its true nature. "The impressions of sense," says Whewell, "unconnected by some rational and speculative principle, can only end in a practical acquaintance with individual objects."

For this reasoning process data are in the first instance required. These data, obtained from a systematic and scientific investigation and recording of the varied experiences of microscopic vision, considered, so to say, in the abstract, are of the highest importance, and would in time serve to render microscopic observation almost wholly free from the fallacies and uncertainty which now beset it.

Although it is a stereotyped expression of our authors that in the case of the microscope "seeing is not believing," the subject is left with the vague warning, that "no rules can be given for the avoidance of such errors, since they can only be escaped by the discriminative power which education and habit confer."*

I venture to think, however, that there can be no difficulty in framing such rules. It is only necessary that microscopists who have acquired the power referred to should record the results of their discrimination and experience.

If each observer keeps the results of his observations for his own exclusive use, little or no advance will of course be possible; but progress will be greatly accelerated if such records are made, for new workers are able to take up their investigations where their predecessors left off, and not only avoid the waste of time and misdirection of energy involved in going again over ground already exhausted, but also the discouragement which necessarily arises from the uncertainty whether what they propose to do has not been done before. One of the most useful offices of such a Society as ours is the assistance it is able to give to this object, so that it is not necessary that anyone should write a complete treatise on the subject, but by means of our 'Proceedings' can note isolated facts for the use of future students.

The phenomena to be investigated range over a very wide field, and it is not possible within the limits of this paper to present a complete analysis of the subjects in regard to which systematic investigation would be valuable.

Among them would be the appearances presented in consequence of the refraction of light by objects of various regular or irregular forms, spherical or cylindrical, with waved or other

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* Carpenter, 5th ed., p. 195.

surfaces, hollow or solid, and of different densities. The effects produced by the reflection of light from objects in numerous modes. The varied and deceptive appearances brought about by the interference of light, a subject which in England, at any rate, is in its relation to the microscope almost untouched. The effects produced by double refraction and polarization. The variations, in differing circumstances, in the colours of bodies. The large range of phenomena involved in the appearances presented by the same object with different kinds of illumination, or in media of different refractive powers. The determination of the indices of refraction and dispersive powers of objects (matters which materially aid in the determination of their true nature). The discrimination of holes from mere depressions, and other variations of structure.

A few clearly settled generalizations would enable a large group of phenomena to be resolved.

As an example of the way in which what is only one small item of this subject may be treated, I may refer to the discussion by Nägeli and Schwendener of the interpretation of the image of a hollow cylinder, a typical form of microscopic object.

They discuss the theory of the formation of the image in four groups:—

1st. The peripheral rays which traverse the walls of the cylinder without entering the cavity.

2nd. The peripheral rays which strike the internal surface of the cylinder very obliquely, and are there reflected.

3rd. The rays which penetrate into the cavity of the cylinder and are reflected on the walls, then arriving at the objective after having undergone two refractions (that is in all, four refractions and one reflection).

4th. The rays which traverse the cavity of the cylinder in a straight line and undergo a quadruple refraction.

Thus is shown on theoretical principles the appearances which such objects will present in different media, or in the other varying conditions in which they may be placed.

I have disclaimed the necessity of having to prove the practical use of such investigations; but "without prejudice" (as the lawyers put it) to that position, I may ask if it can be doubted that such generalizations would be of the greatest assistance to other observers, and the practical results important and useful?

There are numerous instances of the way in which the appreciation of purely optical or physical principles has served in the past to elucidate biological questions, and may serve to elucidate others in the future. I remember having read (though I have been unable to verify the passage) that Harvey himself attributed his discovery of the circulation of the blood to the investigations he had previously made on the pressure of liquids in tubes.

So simple a matter as the experiences of Welcker on the effects produced by globules of air or oil immersed in a fluid of greater or less refractive power than themselves, has enabled subsequent observers to distinguish more readily and with more accuracy elevations from depressions, and to determine the true structure of a large class of objects, so that vacuoles need no longer be mistaken for nuclei.

The supposed tubular structure of human hair can be shown to be erroneous by the application of such principles, and the belief in the solidity of the lacunæ of bone was disposed of by a consideration of the refractive effects of Canada balsam.

The determination of the refractive index of a substance will often show that it belongs to one class of bodies, such as the albuminoid, and not to another, and enables proper deductions to be drawn of the real as opposed to the apparent size of cavities, such as those in the interior of starch grains. If an object exhibits double refraction it cannot be fluid, and the examination of muscular fibre by polarized light will determine whether it is at rest or in the state of contraction.

A paper by Mr. Lowne, just read before the Royal Society, on the "Eyes of Insects," will furnish another instance of the assistance the naturalist would derive from being able to refer to an established theory of microscopical observation, an important part of the conclusions come to in the paper turning upon the results of experiments on the effects manifested by the transmission of light longitudinally through glass tubes and threads.*

Our friends the histologists have arrived, as some of them conceive, at the limit of the resolution of structure; and my senior colleague, who is ready to seize with such avidity on any process that seems to indicate the possibility of further knowledge on histological subjects, would, I am sure, rejoice if he could be guaranteed the power of determining more of the ultimate structure, say of a muscular fibre, than he is now able to do.

I believe that guarantee might be given if the work I am advocating were undertaken, and that it would be found in the result that the histologist best grounded in such work was the best authority in the determination of structure,† and many at present obscure problems would be in a fair way of solution.

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* Since printed in 'Proc. Roy. Soc.,' vol. xxvii. 261.

† Since this paper was written I have seen the lecture on "Microscopes" (in vol. i. of the 'Science Lectures at South Kensington'), by Mr. Sorby, F.R.S., the late President of this Society, in which he points out (p. 203) that "much may be learnt by the study of mineral structures, since in the case of crystals and of solid portions of glass and other analogous objects we know what their character is, whereas in the case of minute organic structures we have rather to infer what is their structure from what we see; therefore, in forming some general idea of illumination, I think we may learn a great deal by studying what we see in small crystals and in inorganic bodies of pretty well known form." And

It would be no less a "practical" benefit if we were able in future to avoid some of the mistakes of recent years. Amongst these may be mentioned the views held up to the present day, that the resolution of lined objects depends upon the shadow cast in consequence of the obliquity of the light. Mr. Stephenson has reminded me of the derision (in which I joined) with which the object-glass of Mr. Tolles, with its marked aperture of 180°, was received; and yet at that time the demonstration existed that the effective angular aperture of an object-glass may readily exceed 180°.

Another instance may be found in that vexed question of a few years since, the Aplanatic searcher. At the time it did not seem to me unreasonable in theory that the defects of an object-glass might within limits be neutralized in the way proposed. The practical reason for not accepting the invention was the absence of results in the hands of anyone but its inventor; but no one was able to expound the principles, then well known elsewhere, which showed that its theory was unsound. If we had been aware of those principles we should have been able to discuss the claims of the invention in an intelligent manner and without having to depend solely on the want of results.

What seems to me to make the subject the more tempting is, that it is virgin soil; any of us who will take it up will not find it has been occupied before him, and the Society in receiving the results will not be in close competition as they are now with other Societies,—in fact, we should then be working in a field of our own, the want of which has been so often bewailed among us.

The examination of diatom valves and Podura scales has undoubtedly been the cause of many improvements in object-glasses, and the indiscriminate abuse sometimes showered upon the observers is to a great extent undeserved: at the same time it is certain that there has been much misdirection of time and energy in such examinations, so far as the end proposed has been only to see with one glass for the hundredth time as nearly as possible what has been seen a hundred times before by a hundred other observers. Such examinations, if properly directed, would have advanced the knowledge of microscopical phenomena in general many years.

Of the two great methods of scientific inquiry, observation and experiment (or as they have been otherwise termed, "passive and active observation"), we have, I think, confined ourselves too much

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again (p. 207), dealing with the effect of a particular kind of illumination on mineral structures, he says that it "would be equally applicable in the case of rods and minute fibres, and such kinds of structures as are commonly met with in organic bodies." And (p. 209), "Such general conclusions are more simple and obvious in the case of mineral structures, but are by no means confined to them . . . . and I cannot but think that much remains to be learned even in the case of more purely organic structures."

to the first, to the disregard of the second. So long ago as the time of Fontana, he wrote, "It is easy to view the image which is offered to the eye, but not so easy to form a judgment of the things that are seen, as an extensive knowledge of the subject, great patience, and *many experiments* will be found necessary for this purpose, for there are many circumstances where the images seen may be very similar, though originating from substances totally different, and it is here the penetration of the observer will be exercised to discover the difference and avoid the error."

To quote Sir John Herschel once more: "It has been found invariably that in those departments of physics where the phenomena are beyond our control, or into which experimental inquiry from other causes has not been carried, the progress of knowledge has been slow, uncertain, and irregular; while in such as admit of experiment, and in which mankind have agreed to its adoption, it has been rapid, sure and steady." *

In microscopy experiment is, of course, more difficult of application than it is in some other branches of science, but there is still ample room for it; many instances will readily occur to you, such as those of the late Mr. Richard Beck on the Lepisma scales, Mr. Slack's silica films, and others, which have now and then appeared in our 'Proceedings.'

It may be that the work I suggest has already been in great part done; if so, it has not been recorded, and for all useful purposes might as well not have been done. It may also be that it is not so inexhaustible as I suppose; in that case there is the less reason for not exhausting it. Whilst I do not hold the view which some people in this country are fond of pretending to hold, that nothing valuable is to be found at home, and that everything abroad is necessarily of superior merit, we may at least set before us, as a goal worthy of being reached, the attainment of a position in our own particular branch of science on a level (to say the least) with that of other countries.

I know that those amongst you who hold my views are comparatively few in number. I have, however, put them forward now so that what it is we advocate may be understood, and others may possibly thereby be converted to the true faith. However erroneous or fanatical those views may be considered, I cannot think that any harm can result from thus stating them.

To the retort, "Physician, heal thyself," I can only say that it is a matter of no small regret to me, that with every inclination to lead the way, an insuperable barrier should be presented by the exigencies of my particular avocation, which not only reduce to small proportions my leisure hours, but render it necessary that those hours should be mainly employed in a recuperative process;

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* 'Discourse on the Study of Natural Philosophy.'

one evidence, however, that I can give of my sincerity is, to undertake a matter which I believe the Society would be doing good service to microscopy if it undertook itself, but which it can hardly be expected to undertake if it does not believe in its necessity, and that is to enable English microscopists to read in their own language one of the best modern German treatises—one which (as a deceased colleague on the Council of this Society declared) is "a mine whose treasures might occupy many workers in developing."

Whilst it does not pretend to be exhaustive, it will at least serve (to put it no higher) to show how extensive a field a complete knowledge of the subject embraces, and until we are able to improve upon it, it will, I think, worthily supply the want which just twenty years since was referred to in an article in the 'Quarterly Journal of Microscopical Science': *—"The period has not yet arrived when all those who employ the microscope methodically as a means of scientific investigation possess an intelligent comprehension of the principles on which it is constructed and the nature of its powers as an optical instrument. There is a large region beyond mere manipulation into which few apparently care to enter. The writers of our introductory treatises leave the matter pretty much as they found it. Surely the time has arrived which calls for more than this; when an optical treatise on the microscope, worthy of the name, is not only desired by the few but required for the many."

When completed, the Society will be better able to judge whether I have exaggerated in what I have written. I have a strong conviction that the conclusion will be that I have not, and I have a strong hope that in the result a new departure will be made in "microscopy" in England.

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* "On the Optical Powers of the Microscope," by P. G. Rylands, vol. vii. p. 27.

III.—*On a Species of Acarus of the genus Cheyletus, believed to be new.* By A. D. MICHAEL, F.R.M.S.

(*Read before the* ROYAL MICROSCOPICAL SOCIETY, *May* 1, 1878.)

PLATE VI.

IN the latter part of December, 1877, being on a visit to some friends near Tamworth, Warwickshire, I found, by sweeping the walls of their beer-cellar, a tolerably plentiful supply of that interesting and beautiful acarid *Glyciphagus palmifer*, which had not before been found in Britain (and which I have announced elsewhere). I was at first occupied with *Palmifer*, but soon discovered that there was a predatory mite feeding upon them. A short inspection satisfied me that it belonged to the genus *Cheyletus*, and I soon saw that it was not any species that I was acquainted with. Subsequent search (as far as I have been able to carry it) has entirely failed to discover any record of the species, which I therefore presume to be new, although it is quite possible that some one may have observed it whose record I have not found.

The state of our knowledge and bibliography as to *Cheyletus* seems to be as follows:—

Latreille * first mentioned, named, and described the genus.

Schrank † mentions; Dugés does not.

Koch ‡ gives it, and treats of the generic characters and habits; and describes and figures five species in a manner sufficient for identification. He does not in any way deal with the sexes, nor with the larval or pupal states. His species are *Ch. eruditus* (and *casalis*, which he regards as a variety); *Ch. venustissimus* (which I have dealt with below); *Ch. hirundinis*, and *Ch. marginatus*.

Gervais § gives *Eruditus* and *Marginatus* only, and practically simply refers to Koch.

Guerin ‖ also copies Koch.

Laboulbéne ¶ mentions a species which he calls Mericourti, of

DESCRIPTION OF PLATE VI.

Cheyletus flabellifer.

FIG. 1.—Upper side of female × about 125.

FIG. 2.—Under side of female × about 125. *a.* One of the main tracheal trunks. *b.* Palpus. *c.* Lateral mammillary process. *d.* Anus.

FIG. 3.—One of the fan-shaped hairs highly magnified.

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* 'Histoire naturelle des Crustaces et des Insectes,' viii. 54.

† 'Enumeratio Insect. Aust.,' 1058, pl. xi.

‡ 'Deutschlands Crustaceen, Arachniden, &c.,' Regensburg, 1839, Heft xxiii. 'Übersicht die Arachnidensystems, &c.'

§ 'Hist. Nat. des Insectes-Apteres,' Walkenaer and Gervais, vol. iii. p. 164.

‖ 'Iconogr. Reg. Anim. Arachnides,' pl. v. f. 8.

¶ 'Ann. Soc. Ent. Fr.,' 1851.

which two or three specimens were found on the ear of a naval officer, near Newfoundland. It appears doubtful whether this is different from *Eruditus.* The late Andrew Murray says that the armature of the palpi appears to be different, but does not say in what respect; the difference may possibly be due to imperfect drawing or preservation.

An account of the mouth, tracheæ, &c., is given by Dujardin.*

Johnston † mentions it, and writes upon *Eruditus.*

Kirby and Spence ‡ (on the authority of Schrank, but still it would seem erroneously) state that the larva has eight legs.

Mr. Brady § found a specimen in the sea, and called it *Robertsoni;* it appears, however, to have been *Eruditus.*

Mr. Beck kept and bred *Eruditus,*‖ the name of which he does not give, and treats of the phenomenon of parthenogenesis with regard to it; but he expressly says that he did not find the male, and he does not describe the larva.

There is a most exhaustive description of the anatomy and physiology of *Eruditus* given by Robin and Fumose; ¶ they, however, expressly say that they have not found the perfect sexual state, but only the larva and nymph. They say that the perfect state is unknown, and this is repeated by M. Robin in 1877, ** but they appear not to have observed Mr. Beck's paper and indeed expressly say that they are not aware that anyone has treated of the subject since Koch.

Finally, Andrew Murray, in his 'Economic Entomology,' gives the genus with reference to Koch, Robin, &c., and a drawing which he marks as being the male copied from Robin. It appears to be a copy of Robin's plate xxii., fig. 2; but Robin expressly says he has not found the sexual form, and Murray does not explain why he calls it the male.

Generic Characters.

These are:—

1. The rostrum, large, sharp, and adapted for sucking.
2. The enormous palpi of three joints, armed with falces and pectinated cirri or styles, forming predatory weapons, and being by far the most conspicuous characteristic.
3. The flattened diamond-shaped body with truncated ends.
4. The legs having five joints, the tarsal being terminated by two claws with a double claw between them, and being furnished with a sucker or else fine hairs on the double claw like a brush.

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* 'Comptes Rendus,' 1844, xix. 1160.

† 'Transactions of Berwickshire Naturalists' Field Club,' vols. ii. and iii.

‡ 'Intro. to Entom.,' vol. iii. p. 107.

§ 'Proc. Zool. Soc.,' 1875.

‖ 'Micro. Trans.,' 1866, p. 30.

¶ 'Journal de l'anatomie et de la physiologie,' 1867, t. iv. p. 506.

** 'Traité du Microscope,' 12th ed., Paris, p. 691.

5. The conspicuous and singular tracheal system with two main trunks, a joint median spiracle at the symphysis of the jaws, and a separate lateral one on the outer side at the base of each jaw.

6. The skin being marked with fine striæ like the Sarcoptidæ—at least on the under side.

7. The predatory nature.

8. The absence of apparent eyes.

Robin and Fumose give other characteristics, such as colour, &c., which appear to me to be rather specific than generic. This need scarcely excite surprise, even with such careful observers, when they state that they have only seen one species. If the distinctions be generic, a new genus would apparently have to be formed for such species as Venustissimus.

The Species believed to be new, which I propose to call Cheyletus flabellifer.

The general and most marked characteristics of this species as distinguished from *Eruditus* are, firstly, its shorter, more thick-set, and powerful form, and the shorter, thicker, and more conical legs; secondly, the hairs along the back a little way within the edge, and most of those on the legs and palpi not being like the fine hairs of *Eruditus*, but being developed into fan-shaped expansions, each set by a short, strong, single stalk into a papilla in the ordinary way, but the stalk soon dividing and redividing into a number of radiating nervures irregularly joined by lateral and anastomosing nervures leaving angular spaces between, and similar nervures round the edge, all of which nervures are joined by a transparent membrane forming a somewhat fan-like expansion, with the radiating nervures projecting beyond the edge, and forming spines. These hairs have a strong resemblance to the leaf-like hairs of *Glyciphagus palmifer*, and distinguish the species at the first glance from all other *Cheyleti* of which I have found any record.

The colour of the creature is semi-transparent, yellowish white, with a median stripe formed by the intestinal canal showing through the skin, but not conspicuously, much like *Eruditus*; the form is a diamond shape, with the anterior half shortest, the front and anal angles of the diamond being truncated and the anal one rounded off, and each lateral angle being formed by a mammillary process on the side of the body, not quite reaching the level of the dorsal or ventral surface, which are much flattened, giving the body the appearance of a flat cake with rounded edges. This shape is characteristic of the genus, but in this species the diamond is shorter than usual, not above one and a half times the greatest width, and the anal truncation is very broad.

On the back, at the widest part, is a broad, transverse, depressed line; in front of this is a space somewhat the shape of an inverted shield with scalloped edges, and behind the depression is a somewhat similar space turned in an opposite direction. These spaces are slightly raised, and occupy almost the whole width of the back; the skin within them and on the upper surface of the first joint of the palpi is closely and irregularly plicated or beaded, giving it a soft appearance; the depressed transverse line, the narrow parts of the dorsal surface beyond the spaces, and the whole under surface of the body and first joint of the palpi are marked with fine waved striæ like the Sarcoptidæ.

The legs are short for the genus. conical, with the coxæ stout, all finely striated except the tarsi, the striæ running round the leg. The foot has the brush on the divided claw (the size of the drawing will not show this).

The first joints of the palpi are extremely large, and form almost square blocks, seeming to hinge near the inner anterior angle, the inner posterior angle being forced into the hollow of the side of the rostrum when the palpus is widely extended. The second joints are much smaller, and are almost elongated right-angled triangles with the points prolonged into strong curved falces and a step cut out of each hypothenuse (the inner) side. At this step the third joints are articulated; they are very small, and almost spherical, and are separately movable, and each bears, firstly (counting from the outside), a long curved falx, longer, slighter, and more curved than that of the second joint, but pectinated on the inner edge for about two-thirds of its length; secondly, a similar one not pectinated; thirdly, a straight spine pectinated up to the point; and fourthly, a recurved hair much shorter. This is the characteristic palpus of the genus, but varies a little in the different species being unusually massive in this one.

The fan-shaped hairs above described, characteristic of the species, are placed as follows: a row of eight down each side of the back, a little within the edge, standing nearly perpendicularly; four across the anal extremity (dorsal surface), and two larger ones lower in level, one on each side of the anus; a very large one on each of the mammillary processes at the side above mentioned, curving downwards, and usually one on each coxa except the second, and two on each of the next three joints of each leg on the outer side standing free, but curving over towards the leg, and two on the first joint of each palpus; these hairs are not all similar, indeed every pair of hairs varies from the others in shape, &c.; but the same hair is alike in different individuals, the distribution on the leg seems to vary a little. An enlarged figure of one of the broader hairs (taken from the leg) is given in Plate VI., Fig. 3. There is a line of six or seven fine, short, ordinary bristles, along each side of the ventral surface, some way within the edge, pointing directly downwards, but not touching the ground.

The vulva is very small and difficult to make out; it is placed about the middle of the body, between the second and third pairs of legs, as in the Sarcoptidæ. I am not at present able to say anything with certainty as to the male organ, or indeed the male at all; I hope to do so hereafter, as I am still breeding the creature.

I have mentioned that I found the species in a dark cellar feeding on *Glyciphagus palmifer.* It is impossible to avoid being struck by the resemblance of these hairs to the leaf-like hairs of *Palmifer* itself, or to refrain from asking the reason of so singular a coincidence in such an unusual peculiarity; and whether it may not possibly be an instance of mimicry useful to the Cheyletus, which, as far as we know, is without eyes, and which certainly lies in wait for its prey, making it less likely to be observed by the Glyciphagus or other mites, and giving it a better chance of securing food; of course it would be entirely premature to express this as more than a possibility until it is seen whether this species accompanies *Palmifer* in other instances besides the present; and with regard to the absence of visible eyes, I cannot help thinking that the Cheyleti have some sense of sight; at all events they are sensitive to light, and one cannot watch them without coming to this conclusion.

This species does not, as far as I have seen, proceed with the jumping action of *Eruditus,* but walks in a steady, determined manner, with the rostrum pointed straight forward and the palpi extended; when actually seizing another mite it makes a short spring upon it.

The tarsus is held perpendicularly, and the front pair of legs appear to act as true legs, and bear their share of the weight (unlike *C. venustissimus*). Nothing could be more ferocious than this mite; the instant it comes across another mite it seizes it with its palpi by any part which happens to be nearest, and then either plunges its mandibles into it at once, or retreats backwards, dragging its captive until it dies, when it is quickly sucked dry; the sucking action may sometimes be distinctly seen, and the contents of the prey traced down the tube formed by the mandibles (or maxillæ), and into the gullet of the Cheyletus. Its own species does not come amiss to it, and when I put together what I hoped were male and female, the stronger immediately killed the weaker and eat it.

The female lays her eggs in a little heap and spins a thick web over them, on which she stands, coming off to feed; the eggs are laid under some cover, and not in the open. I first detected the eggs on 17th of March, at which time they were not yet covered with the web; they were kept in a dark cupboard in a room with a fire, but far from it. The first larvæ were hatched on 6th of April; they are hexapod, with the rostrum rather longer than in the adult; they have the fan-shaped hairs, but not distributed in quite the same manner; there is a row of seven near the edge of the body, but only two at the posterior end instead of four, and the two anal hairs and those on the mammillary processes are larger and more spatula-shaped than in the adult; those on the palpi are the same, but the hairs on the legs are mostly less broadly flabellate than in the adult. Each hair of the first two pairs of the back seems to have a separate motion and to be moved at the will of the creature; the first joint of the palpi is less massive, in other respects the appearance is similar to the perfect form.

I have not found much difficulty in keeping them alive in glass ring cells with a little of material where they were found and a thin cover over. They require to be kept in separate cells, and supplied with food (for which cheese mites answer), and a slight moisture kept in the atmosphere, but not too much.

I propose to call it *Flabellifer*, from the fan-shaped hairs, unless it shall turn out to have been found before.

IV.—*On the Question of a Theoretical Limit to the Apertures of Microscopic Objectives.*

By Professor G. G. Stokes, M.A., D.C.L., LL.D., Sec. R.S.,
Lucasian Professor of Mathematics in the University of Cambridge.

(*Read before the* Royal Microscopical Society, *June* 5, 1878.)

I have just received from Mr. Mayall, jun., a photograph of Professor R. Keith's computations relative to an immersion $\frac{1}{6}$ microscopic objective by Mr. Tolles. I have not at present leisure to go through this long piece of calculation, which I am the less disposed to do as the calculation is perfectly straightforward, and has evidently been made with great care, and I can see no reason to question the result. The only reason for scepticism as to the results of such calculations seems to be a notion derived from *a priori* considerations, that it is impossible to collect into a focus a pencil of rays emanating from a radiant immersed in water or balsam of wider aperture than that which in such a medium corresponds to 180° in air, or, in other words, than 2 γ, where γ is the critical angle.

I do not wish to enter into controversy on the subject, or to criticise the arguments by which this statement has been sustained; I prefer to show directly that it has no foundation.

To disprove an alleged proposition, the shortest and least invidious plan is often to show by one or more particular instances that it is untrue.

Suppose a pencil of parallel rays is incident upon a refracting medium of index μ, and let it be required that it be brought without aberration to a focus q within the medium. By a well-known proposition, the form of the surface must be that of a prolate ellipsoid of revolution generated by the revolution of an ellipse of which q is the further focus, and μ^{-1} the eccentricity, about its major axis, which is parallel to the incident rays. Conversely, if q be a radiant within the medium, the emergent rays are parallel to the axis.

The limit of the incident parallel rays in any section through the axis is the pair that touch at the extremities of the minor axis. Consequently in the reversed pencil the limiting rays are those that proceed from q to the extremities of the minor axis. If we suppose the index to be 1·525, for which $\gamma = 40° 59'$, the extreme rays will be inclined to the axis at the complementary angle 49° 1′. Hence a radiant within glass may send a pencil of aperture 98° 2′, which by a single refraction shall be brought accurately to a second focus at infinity. The double of the critical angle is only 81° 58′, so that the aperture exceeds that supposed limit by 16° 4′.

If it were required that the pencil after the single refraction should converge to a real focus, the surface would have to be generated by the revolution of a cartesian oval instead of an ellipse. If the distance of the point of convergence were considerable compared with the dimensions of the glass, it is evident that the oval would not differ much from the ellipse considered in the first instance, nor would the extreme aperture in glass fall much short of the limit assigned above. Or again, the rays emerging from the ellipsoid might be brought to converge to a second focus q' in air by receiving them on a prolate spheroid of which q' is the further focus and μ^{-1} the eccentricity, and allowing them to emerge from the glass by a spherical surface of which q' is the centre. Or the parallel rays might be brought to a focus without sensible aberration as is done in telescopes.

I do not, of course, propose this as a practical construction of a microscope. It is intended simply and solely to show the fallacy of the supposed limit of 2γ assigned to the aperture, within a medium, of a pencil which can be brought without sensible aberration to a focus in air. As the sphericity rather than spheroidicity of the surfaces employed does not enter in any way into the arguments by which the limit in question is attempted to be established, the spheroidal or cartesian surfaces are quite admissible in argument.

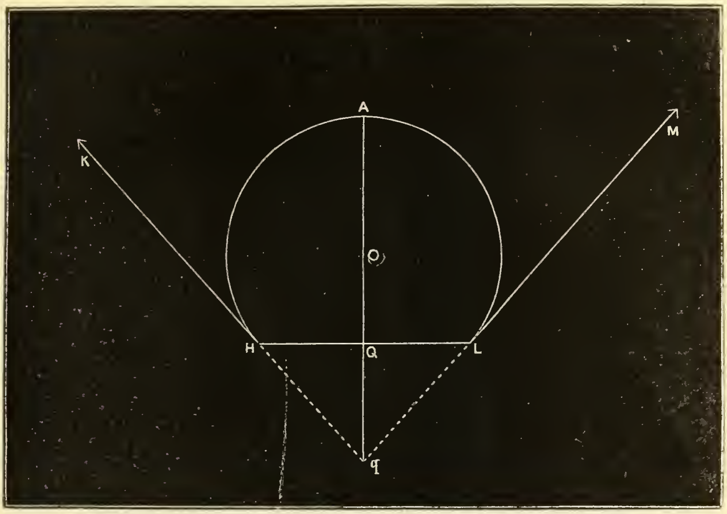
Nevertheless, as an example of what can be done without going beyond spherical surfaces, and as bearing in a very direct way on actual practice, I will take another instance.

Let it be required to make a pencil diverging from a radiant point Q in glass diverge from a virtual focus q after a single refraction into air.

If P be a point in the required surface, $\mu\,\mathrm{Q\,P} - q\,\mathrm{P}$ must be constant, which gives, according to the value we arbitrarily assign to the constant, an infinity of cartesian ovals, any one of which, by its revolution round Q q, would generate a surface which may be taken for the bounding surface of the glass. In one particular case the oval becomes a circle, namely, when the constant $= 0$, in which case we have a circle cutting the line Q q internally and externally in the ratio of 1 to μ.

This case is represented in Fig. 1, in which O is the centre of the circle H A L, which by revolution round the line q Q A generates the sphere. Rays diverging from Q within the glass proceed after refraction at the surface of the sphere as if they came from q. To find the limit of the pencil, we have only to draw the tangents q H K, q L M, and H K, L M will be the extreme rays after refraction. The incident rays Q H, Q L corresponding to these are inclined to the normals O H, O L at the critical angle. It is easy to prove (as will appear from the postscript) that the lines Q H, Q L are prolongations of each other, so that the aperture *in glass* of the pencil which, after refraction into air, diverges without aberration from q is 180°. The aperture H q L of this pencil, after refraction into air, is 2γ, which with the above value of γ, for which the figure is drawn, comes to 81° 58′. Setting aside chromatic variations, the refracted rays proceed, of course, as if they came from q, forming a pencil of aperture 81° 58′. A pencil of aperture in air no greater than 81° 58′ is one which all parties allow can practically be brought to a focus; it could be brought *exactly* to a focus by the use of surfaces other than spherical.

Fig. 1.



The spherical surface of no aberration accords with the form of the first lens to which the makers of immersion objectives have been led. By reducing somewhat the excessively large segment of a sphere represented in the figure, say reducing it to a hemisphere, the space gained in front (of thickness QO if the reduction be to a hemisphere) is available for the cover or interposed balsam, which have both nearly the same index as the crown glass of the first lens; and the aperture in glass, though reduced from the extreme of 180°, still remains very large.

P.S.—The property of a circle employed in Fig. 2 admits of being proved in a few lines, and it might be convenient to the reader to have the demonstration.

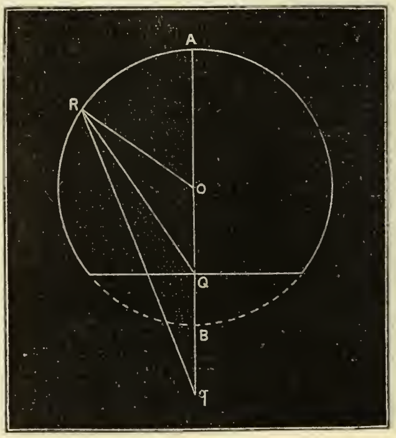
Let O (Fig. 2) be the centre of a circle of which AB is a diameter. In OB take a point Q, and in OB produced take a point q so that Oq is a third proportional to OQ and the radius. Let R be any point in the circumference, and join QR, qR, OR.

Since the radius is a mean proportional between OQ and Oq, we have in the two triangles QOR, qOR, which have a common angle at O, $QO : OR :: OR : Oq$. Therefore the triangles are similar, and $QR : qR :: OQ : OR$; and also the angles OQR, OqR are equal to qRO, QRO, respectively. Hence

$$\text{Sin.}\, qRO : \text{sin.}\, QRO :: \text{sin.}\, RQO : \text{sin.}\, RqO :: qR : QR :: OR : OQ.$$

If then Q had been taken so that $OQ : OB :: 1 : \mu$, where μ is the index of refraction of a sphere of which O is the centre and O B the radius, a ray Q R proceeding from a point Q within the medium would after refraction proceed along *q* R produced. The limiting position of R is when *q* R O is a right angle, or *q* R a tangent to the circle, which is when R Q O is a right angle, since then the sine in the angle of incidence = Q R : R O = 1 : μ, so that Q R O is the critical angle.

Fig. 2.



V.—*On the Results of a Computation relating to Tolles' $\frac{1}{6}$ Objective.*

By Professor R. Keith.

(*Read before the* Royal Microscopical Society, *June* 5, 1878.)

Having received from Mr. Tolles, at the request of Mr. Mayall, jun., the elements* of the $\frac{1}{6}$-inch immersion objective made by him for Mr. Frank Crisp, I have made a computation of its angular aperture (Plate VII.), and present a figure accurately representing its different lenses and their distances apart, and also the path of a ray of light, emanating from a focal point 10 inches behind the objective, and coming to a conjugate focus, free from aberration, 0·01620 of an inch before the front lens.

As a result of the computation, I find that when the objective is used with the thickest cover possible making balsam contact with the front lens, its aperture is 110° 11′ 40″. Under the same conditions the focal distance of the outside rays is 0·01620 of an inch, and of those near the axis 0·01618 of an inch, showing practically no aberration. The computation is made with more precision than is warranted by the nature of the elements, which are necessarily given to only two or three places of decimals, accurate enough, however, for the main purpose.

As the objective is thus shown practically free from aberration at the same time that its balsam aperture is far beyond that which corresponds to 180° of air-angle, the only impropriety in calling its air-angle 180°, for the purpose of comparison, is in the fact that such a statement does not do justice to the objective.

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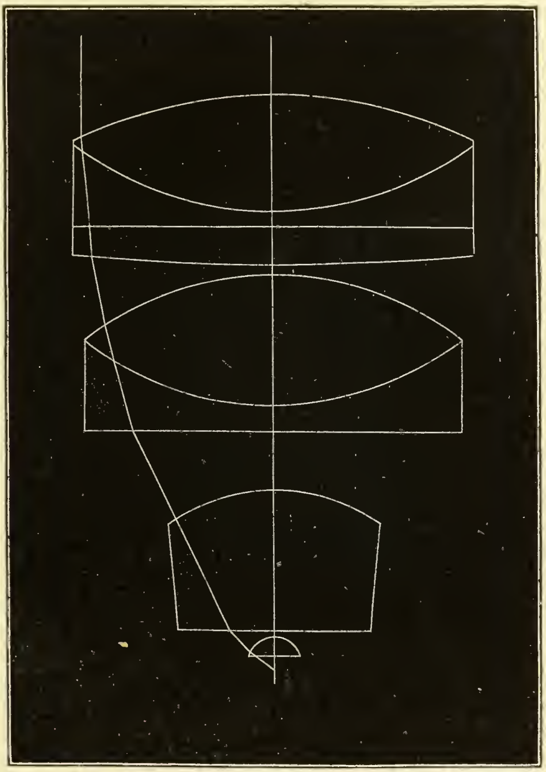
* With the computation Professor Keith wrote:—"Mr. Tolles has been liberal of his time in making the elements sure in every point; going so far as to make, from his memorandum in the case of Mr. Crisp's lens, a new objective in order to be more sure of the distances of the lenses apart and the final focal distance. These are not necessary as elements of the computation, but afford a very decisive confirmation of the correctness of the figuring."

The use of water instead of balsam, and perhaps the "setting" of the lens next behind the front, will slightly reduce the angle above given, but not by any material amount.



The objective, as will be seen in the figure, is composed of seven lenses. Lettering them in order, from the back towards the front, the elements, as given by Mr. Tolles, are as follows:—

	a	*b*	*c*	*d*	*e*	*f*	*g*
Refractive index	1·525	1·66	1·525	1·525	1·62	1·525	1·55
Radius of 1st surface	0·52	0·40	∞	0·35	0·35	0·23	0·029
,, 2nd ,, ...	0·40	∞	1 80	0·35	∞	∞	∞
Thickness at centre	0·132	0·02	0·045	0·145	0·03	0·155	0·025
Diameter	0·46	0·46	0·46	0·43	0·45	0·22	0·053

The distances between *c* and *d* and between *f* and *g* are given by Mr. Tolles as very small, but not recorded in his memorandum; I have taken for the first 0·01 and for the second 0·006 of an inch. The adjustable distance between *e* and *f* Mr. Tolles gives as 0·07 when adjusted for a cover 0·014 of an inch thick. I have used 0·065 of an inch, which slightly increases the aperture, and is theoretically correct for balsam contact, or a cover 0·016 of an inch thick.

NOTES AND MEMORANDA.

Insect Digestion and Development.—The Commission of the French Academy, reporting upon the researches of M. Jousset de Bellesme, to whom the Thore Prize was assigned, make the following remarks:

Until lately the phenomena of digestion in insects were but slightly illustrated by experience, although some observations inclined to the belief that the stomach fluid of insects had the same properties as that of vertebrates. Researches on the Arachnids, animals closely allied to insects, seemed to confirm this opinion. A foreign *savant*, known for some good work, was however led to affirm that the digestion of insects, whether carnivorous or phytophagous, was effectuated under conditions different from those of vertebrates, and he regarded the secretions of their digestive tubes as neutral or alkaline. M. de Bellesme has made fresh observations, which appear quite decisive. Seeing that serious errors are easily made in endeavours to collect the fluid secreted by the stomach, he selected insects, such as Blattidæ, which have stomachs with sufficiently large cæcal prolongations to allow of the gastric juice being extracted without admixture of other matters, and by these means he has shown that the digestion of albuminoid substances takes place solely in the stomach, as in the case of higher animals. He has produced artificial digestions with the acid fluid taken from the cæcal tubes of the stomach.

By experiments of a similar kind he has demonstrated, as most naturalists supposed, that the sole agent for the digestion of amylaceous substances is supplied by the salivary glands.

Another question in insect life has also received from him a final solution. Observers have often been astonished to see a winged insect of considerable dimensions emerge from a comparatively small pupal envelope. The ant lion affords a striking example, and still more so the dragonflies and butterflies. At this moment the air filling the tracheal tubes, and a sudden activity of the circulation giving rise to pressure upon the still soft tegumentary parts, seemed to explain the increase of volume, but there was still a difficulty in understanding how the wings were unfolded, and on this point the observations of M. de Bellesme on dragonflies are conclusive.

When witnessing the development of flies, Réaumur admitted that air was introduced to expand the wings. He said, "the insect drinks in air to fill his body." Evidently he took no account of the way in which the air made its entrance into the insect's organism, and for this reason many authors imagined the remark of the great naturalist to be without scientific value. Some observers considered the expansion of the body and the unfolding of the wings to be caused by pressure of the blood, and the fine researches of Mr. J. Künckel on Volucella demonstrated that an afflux of blood had the result of enlarging the head and producing an extension of the wings. He attributed the movement of the blood to the contractions of the thoracic muscles. No doubt, when a fresh activity affects the whole organization, the muscles enter into play; but the animal is in repose—it has not yet taken flight—the muscular action seems too feeble to account for the powerful results that are seen.

M. Bellesme made his principal study on *Libellula depressa*, and watched its disengagement from the pupal envelope. He saw the body swell out, then the head enlarge, the eyes grow round, and the wings spread out in an uniform manner. At the moment of extreme distension, the volume of the body exceeded the dimensions it retained. While these phenomena were observed, little air penetrated the respiratory organs, but a slight prick of the abdomen produced instant collapse. In dissecting the swollen insects under water he always found the digestive tube filled with air and prodigiously extended. When the dragonfly disengaged his head from the pupal envelope, it took in air by its mouth as Réaumur supposed, and soon accumulated a considerable supply in the œsophagus, stomach, and intestine. In its dilatation the digestive tube drove the blood vigorously towards the sides of the body, towards the head, and the appendages, and by these means expanded the wings in a few minutes. Soon after the intestinal canal emptied itself, the body became flatter, acquired its true form and coloration, and respiratory movements were established. To leave no doubt as to the part performed by the air that entered the mouth, a simple experiment suffices. At the right moment let the entry of the air to the digestive tube be arrested, or let it escape by a prick. In each case the wings do not unfold, or they stop expanding.*

Improvements in the Rivet-Leiser Microtome.—As this microtome has an increasing reputation and is becoming more widely known, it will not fail to prove interesting if some material improvements which have been made in it are published; they have all stood a thorough test, in every way, in trials made at the Zoological Institute. Everyone has experienced that when the object gets in a certain position the knife has to be drawn too far back, in which case it may easily happen that the knife-carrier slips out of its place and falls with the knife on to the table or into the lap of the operator. In the first case the knife only is damaged, but the second case is positively dangerous, as the carrier is of considerable weight, and it is a common though a bad habit to clutch instinctively with the hands anything falling off the table. This defect is remedied as follows:—In the perpendicular side of the rut for the knife a horizontal groove is made, stopping short of the farther end, and about 1·5 mm. deep. On the knife-carrier is a knob, which moves without friction in the groove during the process of cutting. It is evident that when the knife is drawn too far back the knob comes to the end of the groove, and the knife is prevented from falling out.

The object to be cut, as is well known, can only be raised 1 centimetre by the inclination of the sloping plane. When the object is larger it becomes necessary to loosen the screw and fix it higher. A number of suitable metallic plates have now been made which, when the cutting is commenced, are laid under the knife and screwed fast to it. When the object has been brought to the top, one or more of the plates are removed from beneath the knife, so that the latter sinks lower, according to the thickness of the plates; and the object requires, consequently, only to be drawn back again to enable the cutting to be continued.

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* 'Comptes Rendus,' Jan. 7, 1878.

In addition to this, the instrument has been made larger (it measures 18½ cm. in length), by which means the object to be cut may be considerably longer.

The most important drawback hitherto, however, was not being able to alter easily the direction of the section when the object was once screwed down. The whole object had to be taken out every time, and the body in which it was imbedded differently shaped. Those who have had to make longitudinal sections through hairs, &c., know what that is. Besides this, with the old arrangement it was quite impossible to make oblique sections through their whole length of embryos which were at all curved. It was generally the case that the sections gradually took another direction with respect to the longitudinal axis, and not unfrequently the oblique section passed finally into a frontal section. In the modified instrument the clamp for the object is now fastened to a round socket; by this arrangement it becomes possible to alter with great rapidity the inclination of the section in every direction, at least within certain limits, more extensive however than most objects require. The great advantage of this arrangement is self-evident. The round socket ought to be kept oiled with good machine oil, and the clamp screw which acts on a lever to fix the round socket must never be screwed too tight. The foot is not made of cast iron, as before, but is a heavy brass plate. It is best to have four knives, two straight and two angular. With these improvements this instrument places even a novice in a position to produce excellent sections in the course of a short time.*

The Movement of Microscopic Particles suspended in Liquids.—Professor Stanley Jevons records in the 'Quarterly Journal of Science' for April, under the above title, the result of the investigations he has made on this subject. He objects to the names "molecular movement," "Brownian movement," or Dujardin's "titubation," and suggests "*pedesis*," from the Greek πηδησίς, leaping or bounding. The best possible exhibition of the motion is to be got by grinding up a particle of pumice-stone in an agate mortar, and mixing it with distilled water. The minute angular particles will be seen under the microscope to leap about with an incessant quivering movement, so rapid, that it is impossible to follow the course of a particle. The substance most convenient for experiments, he considers, however, to be fine pure china clay or kaolin, a small quantity of which shaken up with pure water makes a milky liquid, a drop of which will show the motion in great perfection. He considers that he has completely disproved the suggestion that the motion is excited by rays of light or heat falling upon the liquid, or that it is connected with the shape of the particles; and from the observations he made on the length of time during which the motion will continue, he disagrees with the opinion recently expressed by Professor Tyndall that it is due to surface tension. He then proceeds to point out the intimate connection between pedesis and suspension of particles in liquids. In the absence of pedesis, suspended particles attract each other and become aggregated together into little groups, which then acquire sufficient weight to force their way down through

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* Dr. H. Reichenbach, Assistant to the Zoological Institute of Leipzig University, in the 'Archiv für Mikroskopische Anatomie,' xv. 1.

the resisting liquid; pedetic motion prevents the formation of groups, and keeps the minute particles apart so that each encounters the separate resistance of the fluid.

Pure water exhibits pedesis in the highest perfection, even the air and carbonic acid usually dissolved in it producing a perceptible difference. If, however, instead of mixing china clay with pure water, it is mixed with a very dilute solution, say one part in a thousand of sulphuric acid, the pedetic movement is almost entirely destroyed, the same effect being produced by almost any mineral acid, and as a general rule by all salts and other soluble substances. To this general rule, however, there are certain remarkable exceptions, such as pure caustic ammonia (but not its compounds), boracic acid, and silicate of soda—gum arabic even possessing the power of increasing the motion. Comparing the substances which do not prevent the motion with those which do, it becomes apparent that, with some doubtful exceptions, they differ widely in the power of making water a conductor of electricity. Faraday found that some acids, such as the sulphuric, phosphoric, oxalic, and nitric, increase the conducting power of water enormously, whilst others, as the acetic and boracic acids, produce no change; gum and ammonia producing no effect, whilst its carbonate does, and sulphate of soda and many soluble salts producing much effect. The argument in the case of pedesis is, the Professor considers, exactly analogous to that which Faraday employed in his inquiry into the production of electricity by the Armstrong electrical boiler, which he found must be supplied with pure distilled water to yield much electricity. The smallest drop of sulphuric acid or a little crystal of sulphate of soda prevented the evolution of electricity, as also did the addition of any of the saline or other substances which give conducting power to water. As ammonia increases the conducting power of water only in a small degree, Faraday concluded that it would not take away the power of excitement, and accordingly, on introducing some to the pure water, electricity was still evolved, but the addition of sulphuric acid by forming sulphate of ammonia took away all power. "The analogy of these circumstances to that of pedesis is so remarkable," the Professor writes, "that little doubt can be entertained that the same explanation applies. It is perfectly pure water which produces electricity and pedesis; almost all soluble substances prevent both one and the other phenomenon, but ammonia is one of the few exceptions—it allows both of electric excitation and pedesis. Boracic acid is another exception, and gum a third. . . . In spite of some discrepancies and failures, I still think the analogy between pedesis and Armstrong's electrical machine so strong, as to leave little doubt that pedesis is an electrical phenomenon." In attempting to explain the exact *modus operandi*, we can only speculate that the action upon a minute irregular fragment will never be exactly equal all round. In order that a particle shall rest motionless in a non-conducting fluid, it must be in exactly equal chemical and electric relation to the fluid on all sides. That this should happen is almost infinitely improbable, and a condition of unstable equilibrium within limits is the result.

The Professor concludes by pointing out that there is probably a close connection between pedesis and the phenomena of osmose.

A Test Object for Histologists.—Professor Ranvier recommends as a test for objectives intended for histological work (" which are required not for flat bodies presenting only fine striæ, but for objects of irregular and varying forms, rough, concave, or convex "), the isolated muscular fibrillæ of the wings of the *Hydrophili*. With a power exceeding 300 diameters, the alternately thick and thin dark disks which characterize the fibrillæ may be seen.

On the Rhizopoda of the Salt Lake of Szamosfalva.—Dr. G. Entz has described the Rhizopoda obtained by him from a salt pool at Szamosfalva, near Klausenberg, in Hungary. He procured in all twelve species, five of which, all shelled species, are described as new, and two of them as the types of new genera. These are *Pleurophrys helix*, *Plectrophrys* (g. n.) *prolifera*, *Euglypha pusilla*, *Microcometes tristrypetus*, and *Orbulinella* (g. n.) *smaragdea;* the other forms noticed are *Ciliophrys infusionum*, Cienk., *Podostoma filigerum*, Clap. and Lachm., and five species of Amœba.

The majority of the Rhizopods belong to forms which are very common in fresh water, but which must probably be referred to the category of organisms which occur indifferently in both fresh and salt water ; and, so far as this supposition applies to the *Amœba*, Dr. Entz furnishes a confirmation of it in a subsequent short note, in which he states that he found *Amœba limax* and *A. radiosa* very abundantly in sea-water from Cuxhaven. (He regards the marine forms *A. marina*, Duj., *A. polypodia*, F. E. Schulze, and possibly also *Protomœba polypodia*, Hack., as probably identical with *A. radiosa*.)

Of the forms peculiar to the Szamosfalva salt-pool, two (namely, *Euglypha pusilla* and *Microcometes tristrypetus*) find their nearest relations in fresh-water organisms. *Pleurophrys helix*, on the contrary, belongs to a marine type. Of the two new genera, *Orbulinella* is the most nearly related to the marine perforated Foraminifera, and *Plectrophrys* is referred to the neighbourhood of *Pleurophrys*, *Plagiophrys* and *Chlamydophrys*, and may be either a marine or a fresh-water type. As a negative character bearing on the marine or fresh-water affinities of the Rhizopodal fauna of Szamosfalva, the author remarks on the total absence of *Arcellæ* and *Difflugiæ*, both of which are so abundant in, and characteristic of, fresh water.*

The Conversazione of the Royal Society on May 1.—The following objects of interest to microscopists were exhibited :—Dr. Woodward's rectangular prism illuminator, to be used with immersion lenses; and Dr. Edmunds' immersion paraboloid (exhibited by Mr. J. Mayall, jun.). A new form of micro-spectroscope, exhibited and made by Mr. Adam Hilger on a plan suggested by Mr. Sorby. Instead of placing the lens used to focus the slit below the prisms, it is placed just above them, and a cylindrical lens is fixed below, in order to correct the astigmatism. The advantage of this arrangement is that the whole apparatus is very greatly reduced in length; in fact, to about half the usual size. The lens used to focus the slit also serves to focus a graduated scale seen by reflection over the spectrum, which enables the observer to measure at once the position

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* Hungarian 'Naturhistorische Hefte,' 1877, 3 and 4; 'Ann. Nat. Hist.,' May, 1878.

of any absorption band. An improved form of micro-spectroscope (designed and exhibited by Mr. F. H. Ward, M.R.C.S.), the improvements being (1) quick movement of the slide carrying the slit, (2) scale for registering the position of the slit, (3) arrangement for comparing three spectra, or for splitting a single spectrum and inserting a second spectrum between the halves, and (4) new form of comparison stage.

The Soirée of the Chemical Society.—At this soirée, given by the President, Dr. Gladstone, F.R.S., at Burlington House, on May 30, there were exhibited:—A new arrangement of polarizing apparatus for the microscope, in which both the polarizing and analyzing prisms can be readily shifted out of the field, thus allowing the object to be viewed by direct illumination. Apparatus for photographing plates of crystals (ordinary-sized microscopic objects enlarged to 3 inches) by means of polarized light (both exhibited by Messrs. Murray and Heath).

A French view of the Binocular Microscope.—The difference in the appreciation of the binocular microscope by microscopists in England and America on the one hand, and those of France and Germany on the other—in which latter countries Wenham's prism, if not unknown, is at any rate almost wholly unused—is a phenomenon not easily to be accounted for. The following is the view taken of binocular microscopes by Professor Ranvier, of Paris, the leading histologist of the day, in his book, just published, on 'Practical Histology':—" The binocular microscopes give, it is true, the sensation of relief, but they cannot properly be called stereoscopic. What gives the notion of relief is that our two eyes do not see exactly the same image of an object; it is this principle which has been utilized in the stereoscope, in which a different image of an object is placed before each eye so as to produce a single impression. In the binocular microscope, on the contrary, there are not two different images; it is the same image which is presented to each of the eyes of the observer. The sensation of relief is the result of an illusion founded on habit, and consequently this kind of microscope cannot be considered stereoscopic. Moreover, these instruments have the inconvenience of diminishing the clearness of the image, and it is not possible to use them with the higher objectives. The only way of obtaining with the microscope a notion of the relief of objects and of their superposition is by employing the ordinary microscope with objectives of large angle of aperture. As these only allow extremely limited portions of the objects to be seen, we get a complete knowledge of the latter by varying the focus by means of the fine adjustment. The respective situations of two points of the same object and of two different objects will be determined by the impression conveyed by the alteration of the fine adjustment necessary to see them successively. In short, the binocular or stereoscopic microscope, which is a good instrument for demonstration, cannot be employed in histological researches."

The views held by microscopists in this country are, it is needless to say, widely different from the foregoing, and agree with those expressed by Dr. Carpenter in 'The Microscope and its Revelations.'

On p. 59 (fifth edition) he says, "It is easily shown theoretically, that the picture of any projecting object seen through the microscope with only the *right*-hand half of an objective having an even moderate angle of aperture, must differ sensibly from the picture of the same object received through the *left*-hand of the same objective; and further, that the difference between such picture must increase with the angle of aperture of the objective."

"The stereoscopic binocular is put to its most advantageous use when applied either to *opaque* objects of whose solid forms we are desirous of gaining an exact appreciation, or to *transparent* objects which have such a thickness as to make the accurate distinction between the nearer and their more remote planes a matter of importance" (p. 69).

At page 79 the writer draws attention "to two important advantages" he has found the binocular to possess. "In the *first* place, the *penetrating power* or *focal* depth of the binocular is greatly superior to that of *the monocular microscope;*" and in the *second* place, when employed on objects suited to its powers, "the prolonged use of it is attended with *very much less fatigue* than is that of the monocular microscope."

The Revivification of Diatoms.—Mr. Habirshaw, of New York, states that "in 1871, Captain Mortimer brought from San Francisco in his ship a large bottle of diatoms (from fresh water), intending to study them during the voyage. When he arrived in England they were still alive, but afterwards dried up and remained in that state in his cabin until the summer of 1877—a period of six years. Having found the old bottle, which we knew very well, we refilled it with water, and on examining it several days later we found some living specimens in it. At first this phenomenon inspired us with some doubts, but after a subsequent examination we came to the conclusion that these diatoms really were alive. The vessel has gone to sea again, and we await its return to verify anew the facts which we observed." *

A Method of Staining Rapidly.—I have long known that carmine staining acts quicker when the watch-glass containing the carmine and the section was not covered. But there is the disadvantage in this method, that particles of dust settle on the surface of the fluid, and are apt to adhere to the section on its being taken out. I recently tried warming the fluid, in order to overcome this drawback, and also because I thought that the more rapid evaporation of the carmine solution accelerated the colour being taken up, and I arrived by this means at surprisingly favourable results.

After the first attempt had proved successful, I modified the procedure as follows:—Over a water-bath (only partly filled) with a large opening, a wire netting is placed, upon which, as soon as the water begins to boil, the section is put in a watch-glass containing the carmine solution, and exposed to the action of the steam. In the course of from two to five minutes the sections are completely stained. They are then washed twice in distilled water, placed for a few minutes in common alcohol, and for the same time in absolute alcohol,

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* 'Journal de Micrographie.'

and may then be placed under the microscope in oil of cloves. Thus the whole process does not take more than ten minutes.

The sections are not only quickly but well stained, and indeed, as I have found by comparing results, for the most part better even than when submitted to the slow action of the carmine.

I have, however, only treated sections of the central nerve system (brain and spinal marrow of man and animals) by this method, but it ought to be applicable to other structures. It is, of course, understood that the previous preservation and hardening of the preparation must be well done in order to obtain a corresponding staining. For fresh preparations or for preparations in alcohol (which latter are generally to be avoided as much as possible with the central nerve system), this method does not answer; objects colour best which have been hardened in chromate of potash (especially with the addition of a few drops of chromic acid).

Moderate heating does not hurt the preparation; the precipitate of carmine, which might be thrown down by it, may readily be avoided. A neutral ammoniacal solution of carmine, not too concentrated, furnishes all that can be desired.

It is not only on account of its rapidity that I now generally adopt this method, there is in addition the advantage that the preparations thus treated are coloured in a specially sharp and distinct manner; for example, the connective-tissue corpuscles, together with their long continuations into the substance of the brain, which insert themselves in the adventitia of the vessels, come out with a distinctness which it is difficult to obtain by other means.*

A New Field for the Microscopist (*the Flagellate Protozoa*).—In the April number of the 'Popular Science Review,' Mr. Saville Kent, after referring to the improvements which have been made by opticians, in this and other countries, in the construction of object-glasses, and suggesting that "it would be a matter for congratulation if we could place on record side by side with this attestation to the mechanical perfection and improvements of our magnifying instruments, evidence of an equivalent amount of progress achieved by microscopic workers in those new fields for investigation thrown open to them by the skill of the optician," proceeds to give a descriptive outline, with illustrations, of certain of the Flagellate Protozoa—"an extensive series of forms that have so far, on account of their exceedingly minute size, altogether evaded the notice of the microscopists of this country, but which at the same time most certainly surpass all previously discovered types, equally in the wonderful symmetry of their individual form and in that of their aggregated mode of growth, requiring for their satisfactory interpretation the employment of the most powerful and high-class magnifying powers."

It is impossible within the limits of a "Note" to give any intelligible abstract of Mr. Kent's detailed description of some of the forms, for which the paper itself must be referred to. Some of them are described and figured in a paper read by the author before the Royal Microscopical Society, and printed in the 'Transactions' for January 1872.

The close relationship which, as Mr. Kent considers, undoubtedly

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* Dr. H. Obersteiner, in 'Archiv f. Mikroskopische Anatomie,' xv. 1.

subsists between the sponges and the extensive group of independent collar-bearing Flagellate Protozoa, is discussed at some length; and while recommending these organisms to the attention of working microscopists, it is pointed out that it is much to be desired that they should supplement their observations by a practical examination of the structure of all such sponge forms in the living state to which they may have access. In either field our knowledge may be said as yet to extend no farther than the threshold, and in each of the same there is probably more original discovery waiting to be achieved than in any other group of the organic world.

Mr. Kent gives the following hints as to finding these interesting forms. Either salt or fresh water will be found to yield its quota; those frequenting the last-named element being usually the more accessible, will most probably command first notice. The investigator should procure from the nearest weedy ditch or pond a bottleful of the finely divided leaves of *Myriophyllum*, or of tangled confervoid growths, in either case selecting more especially those brown-hued specimens coloured by a dense incrustation of other more minute vegetable and animal parasitic growths. Care should be taken to enclose with the water as large a number as possible of the specimens of *Cyclops* and other Entomostraca, to which will frequently be found attached species rarely, if ever, to be met with elsewhere. Patiently exploring every filamentous division of the weeds with a power of 900 diameters, it will be scarcely possible to miss encountering one or more of the species, which with so low a power will appear as mere luminous specks, and will require a power of 2000 diameters for their proper identification.

The Royal Microscopical Society of the Sandwich Islands.—King Kalakua has recently established in his dominions a Society under the above title; particulars of its constitution and operations are on their way to this country. The king has always given active encouragement to science, and in his honour a new fungus, lately discovered growing on a boat thrown up on the beach near Honolulu, has been named (by Mr. J. P. Moore, of San Francisco) *Polyporus Kalakua.*

Count Castracane on Diatoms.—At a sitting of the Botanical Society of France last summer, Count Castracane exhibited more than 2000 photographs of diatoms magnified 535 diameters, and stated that his entire collection contained about 3000, of which the negatives were carefully preserved. He described his mode of ascertaining the number of striæ in a given space. He projects the image of a millimetre divided into 100 parts, so that the enlargement of each $\frac{1}{100}$ of the millimetre occupies a space on paper of 18 centimetres. "Taking," he says, "a power of this measure, I superpose an image of the diatom, selecting the clearest part, and then determine with certainty and without fatigue the number of striæ that correspond with the space of $\frac{1}{100}$ inch."

His measurements led him to deny that *Navicula crassinervis*, *N. rhomboidea* Ehr., and *Frustulia Saxonica* Raben., belong to the same species. He exclaims, "How could I believe this, when I am assured that in *N. rhomboidea* Ehr. the longitudinal divisions, or, more correctly, the intervals between its rows of granules in the longitudinal direction, are smaller than those between the transverse rows, while in *N. crassinervis* the opposite is observed, and the transverse intervals are much narrower than the longitudinal ones."

Referring to the use of monochromatic light by Amici, he stated that he used "a prism of 35° of flint glass, in which the solar ray is decomposed in immersion and emersion," and that a Paris optician was going to make a cheap and suitable heliostat. He usually employed the blue, or green, or extreme violet rays, but practice was necessary with the latter to get used to the demi-obscurity.*

The New Oil-immersion Object-glass.—The Rev. W. H. Dallinger writes to 'Nature':—"As a piece of workmanship this lens is extremely fine; and it can be used with quite as much ease as an ordinary immersion $\frac{1}{4}$-inch objective. It works admirably with Powell and Lealand's ordinary sub-stage condenser, with Wenham's reflex illuminator, and with the small plano-convex lens which the maker sends with it to be fastened to the under surface of the slide with the oil of cedar wood. But I have also secured admirable results with the illuminating lens of Powell and Lealand's supplementary stage, which gives entire command over the angle of the illuminating ray.

"The spherical aberration is beautifully corrected, the field being perfectly flat. The colour corrections are, so far as the lens goes, equally perfect; but are somewhat conditioned by the dispersive power of the oil, which can be modified readily. The sharpness and brilliance of the definition which this lens yields is absolutely unsurpassed, in my experience; and it has a very great power of penetration.

"I tested it with a series of tests with which I have proved and compared the glasses of various makers in England, the Continent, and America for some years. Up to the time of receiving this lens, the $\frac{1}{8}$-inch that had done the most in my hands, was one of the 'new formula' lenses of Powell and Lealand. It is but justice to say that all my most crucial tests were equally mastered by the lens of Zeiss. I have not been able to do more with it than with the English glass, *but the same results* can be accomplished *much more readily.* The correction has to be brought into operation, and careful adjustment made, to get the finest result with the English lens; but the German glass has simply to be brought into focus, and the best result is before the observer, provided that the light has been adjusted in the most efficient manner. It is true that for sharp and perfect definition we must be careful to adjust the length of the draw-tube; in working this lens there is much need of attention to this matter; and speaking from a practical point of view, it takes the place, in securing crisp definition, of the screw-collar adjustment, although, of course, much easier of application. But it is so easy to work the lens with fine results on the more delicate tests, that I think that those who make the resolution of these their primary object in the possession of a microscope, can scarcely fail in securing their utmost desire. It is a glass pre-eminently suited for the resolution of difficult lined or beaded objects.

"*Amphipleura pellucida* is easily resolved into delicate beads when the frustules are moderately coarse; and almost any that can be met with are resolvable into lines; and this when these diatoms are

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* 'Bulletin de la Soc. Botanique de France,' t. xxiv., 1877.

mounted in balsam. The highest eye-pieces made may be used without any practical detriment to the image, although, of course, with a reduced sharpness of the definition.

"On the whole, I think it in many cases the finest lens, of its power, that I have ever seen; and in every sense it is an admirable acquisition."

In conclusion, Mr. Dallinger refers to "another feature in the use of this lens which is a drawback," viz. that the oil is a solvent of most varnishes and gums used in mounting and finishing slides (which may be remedied by coating the edge of the cover with shellac varnish); and also to the necessity for the objects, such as frustules of diatoms, to be "burnt" on to the cover or mounted in balsam or other fluid with an equal refractive index.

Dry v. *Immersion Objectives.*—In the same letter Mr. Dallinger observes:—"Even water immersion lenses are of very limited service in observations continuously conducted upon minute *living* organisms in fluid. We may gladly call in their aid, in the determination of a delicate change of form, or in the more perfect detection and definition, of an obscure point of structure; but for steady and constant work we are bound to avoid them; for the fluid under the delicate cover is in danger every moment of being 'flooded' by coming into contact with the water on the top of the cover, and between it and the lens; because the movements of the organism have to be counteracted by the movements of the mechanical stage, in order to keep any form that may be studied in view constantly. But this opens to us the possibility of going to the edge of the cover at any moment; and thus, by the mingling of the fluids, rendering the observation void. This, of course, will apply still more fully when, as in the case of the valuable glass of Zeiss, the 'immersion fluid' is an essential oil.

"Happily it is only in special cases that the greater analyzing power, combined with larger working distance, which is possessed by immersion lenses, is required. It is in the earlier study of an organism, and before continuous work upon it has begun. And even if it be not, in the majority of cases a first-class dry English lens of a higher magnifying power, if efficiently used, accomplishes all that is required. Hence the fine 'new formula' lenses, *dry* (also provided with fronts to be used as immersion lenses), are as yet an unsurpassed boon for this special class of work. And certainly it is one which, in relation to biology, has a most important future. I know, of course, that the optician has irresistible limitations to deal with; but the 'new formula' dry lenses I have referred to, prove, in comparison with the preceding lenses, made by the same firm, that the dry lens was capable of most serviceable improvement. What is important, therefore, is that the larger demand for lenses that will resolve readily, difficult lined and beaded objects, which can certainly be best done, all things being equal, with immersion lenses—and to the improved manufacture of which Zeiss' oil immersion gives apparently a new departure—should not lead the best opticians in England, the Continent, and America to abandon efforts for the still greater improvement of their dry lenses. They are of the greatest value to the practical biologist, working amidst the minutest living things in nature, and from the study of which so much may be anticipated."

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Researches on the Probosces of Butterflies. By W. Breitenbach. (With 1 plate.)

Minor Histological Communications. By Dr. P. Schiefferdecker.

Observations on the Anatomy of the Antennæ-Hairs. By Dr. Ludwig Loewe. (With 1 plate.)

On a Peculiar Looped Formation of the Blood-vessels in the Brain and Spinal Marrow of the Saurians. By Dr. Jos. Schöbl. (With 1 plate.)

On the Nerves of the Ureters. By A. Dogiel. (With 1 plate.)

The Development of the Mesoblasts in the Hens. By Dr. J. Disse. (With 1 plate.)

Explanations on the Observations of M. Foster and A. G. Dew-Smith in vol. xiv., No. 3, p. 317. By J. Dogiel.

On the Higher Tissue-theory (Part I.). By G. Valentin.

On the Structure and Efficacy of Glands (Part II.): The Ferment Formation in the Glands. By Dr. Moritz Nussbaum. (With 1 plate.)

Some Improvements in the Rivet-Leiser Microtom. By Dr. H. Reichenbach.

A Method of Staining Rapidly. By Dr. H. Obersteiner.

The ZEITSCHRIFT FÜR MIKROSKOPIE for March:—

The Development and Present Position of Microscopy in Germany (*continuation*). By Dr. E. Kaiser.

On the Staining and Preparation of Bacteria. By Dr. W. A. Haupt.

On the Collection and Observation of Microscopic Objects on Travels and Excursions (*conclusion*). By Dr. E. Bouché.

Review of a book by Dr. E. Strassburger on Fertilisation and Cell Division.

For April:—

Three Botanical Monographs of M. F. Ledermüller. By Dr. J. Grönland.

On Foreign Microscopes (*continuation*). By Dr. J. Pelletan. Translated from the 'Journal de Micrographie.'

The Making of Microscopic Preparations. By Arnold Münster.

SIEBOLD AND KOLLIKER'S ZEITSCHRIFT FÜR WISSENSCHAFTLICHE ZOOLOGIE, Vol. XXX., Supplement, 1st and 2nd parts (issued 23rd April and 1st May):—

The Form of the Crystalline Cone in the Eyes of the Arthropoda. By Oscar Schmidt. (With 1 plate.)

The Poison Apparatus and the Anal Glands of the Ants. By Dr. August Forel. (With 2 plates.)

Contributions to the Knowledge of the Post-embryonal Formation of the Limbs in Insects. By H. Dewitz. (With 1 plate.)

On the Ornamental Colours of the Daphniadæ. By Dr. A. Weissman. (With 1 plate.)

Anatomical and Zoological Observations on Amphipoda and Isopoda. By Dr. F. Leydig. (With 4 plates.)

On the Generative Organs of some Ecto-parasitic Marine Trematoda. By Carl Vogt. (With 3 plates.)

On the Shore-inhabiting Cladocera. By Dr. Wilhelm Kurz. (With 1 plate.)

Vol. XXX., 4th part (issued 7th May):—

On the Origin of the Generative Products in the Hydroida. By J. Ciamician. (With 2 plates.)

On the Structure of Reniera semitubulosa: A Contribution to the Anatomy of the Siliceous Sponges. By Dr. E. Keller. (With 2 plates.)

Contributions to the Knowledge of the Malpighian Vessels of Insects. By Dr. E. Schindler. (With 3 plates and a woodcut.)

The Fibrillæ of the Genus (of Sponges) Filifera (Lieberkuhn). By Oscar Schmidt.

PROCEEDINGS OF THE SOCIETY.

King's College, London, *May* 1, 1878.

H. J. Slack, Esq., President, in the chair.

The minutes of the preceding meeting were read, and were signed by the President.

Professor Abbe, of Jena, was balloted for, and unanimously elected an Honorary Fellow of the Society.

A list of donations to the Society was read, and the thanks of the meeting were voted to the donors.

Mr. C. Stewart (Secretary) then read a paper "On a new British Cheyletus," by Mr. A. D. Michael. The paper was illustrated by carefully executed drawings, and minutely described the structure and habits of the insect, which it was proposed to call *Cheyletus flabellifer.*

The President, in proposing a vote of thanks to Mr. Michael, called attention to the very beautiful illustrations with which the paper was accompanied, and observed that he had himself found another species recently in the bark of cherry trees, which at the present time of year contained a large number of small insects, such as mites of various kinds, Chelifers, spiders, Poduræ, &c.

Dr. Braithwaite suggested the desirability of bringing forward such papers as the one which had just been read, and urged upon the Fellows generally that they should not content themselves by merely subscribing to the Society and attending the meetings: there was much to be done in the way of similar observation and descriptions. This family of the Acaridæ, especially, opened up a wide field for investigation, and the same might be said of the Cryptogamia and other botanical subjects. Now that their new Journal was being started, it was very desirable that Fellows should encourage it by working out small monographs on various subjects similar to the one they had just heard.

Mr. S. J. McIntire, in reply to a question from the President, said that about twelve years ago he had given some attention to the subject, and had then met with two species of *Cheyletus*, one of which was *C. eruditus*, and the other was thought not to have been before described. With regard to colour, he had at that time observed that a quantity of Cheyleti found behind a cage where some birds were kept, were of the same red colour as the bird mites upon which they had been feeding, and not of their usual orange colour.

Mr. Stewart inquired if the red colour was diffused all over the insects, or whether it was merely seen through the course of the alimentary canal?

Mr. McIntire said it was generally diffused, but when the insects had been feeding the darker course of the alimentary canal was clearly marked.

The President inquired whether it was also the case with regard to mites as with spiders, that they would attack and eat one another up?

Mr. McIntire said that, as a rule, any mite would eat up another which was not strong enough to defend itself.

The President said that they had received a very important paper upon blood-corpuscles, which, however, it was impossible to read *in extenso*, especially as it was illustrated by numerous drawings, apart from which it could not be very readily understood. Mr. Stewart had, however, carefully read the paper, and would give them a *résumé* of its contents, and the paper itself would appear in full in the Journal.

Mr. Stewart said that the paper in question was in continuation of one formerly read before the Society upon blood-corpuscles, and which was already in print. They would probably remember that the author (Dr. H. D. Schmidt, of New Orleans) then described his observations upon the blood of man, and he now proceeded to follow this up by some further remarks, and to make comparisons between what he had seen and the blood of the Amphiuma, frog, and of man. Mr. Stewart then, by means of drawings on the black-board, described the chief points of the paper, and indicated the line of argument taken and conclusions come to by the author.

The President proposed a vote of thanks to the author of the paper, and also to Mr. Stewart for the very excellent description which he had given of it. Carried unanimously.

The President called attention to the Scientific Evening which it had been arranged should be held on the 15th instant, and urged upon the Fellows the desirability of their bringing up their instruments with any objects of interest upon the occasion. He hoped that no effort would be wanting to secure a good attendance and make the meeting a success.

The President said that it had been thought that their ordinary meetings might be made more interesting if, after the papers had been read, the Fellows would bring forward any notices of objects of interest which might have come before them, or of any matter relating to their microscopical pursuits upon which it might be desired to obtain any further information. With a view of setting the example, he would just mention two little matters which might serve to start this plan amongst them. He believed that at the present time specimens of the very beautiful Lissajou's curves, drawn microscopically by Mr. West, could be obtained, and he would strongly advise Fellows who were interested in the matter to get them, with a view to the solution of some curious questions of interpretation. If they procured a specimen of these curves in which the lines crossed one another more or less obliquely, and began to examine it with a 4-inch objective, illuminating it with a larger spot lens than usual, they would get some very beautiful effects of colour, but they could not obtain a really correct view of the object itself, because of the very striking character of the false perspective, which made it seem as if one set of curves passed a long way behind the others. It seemed to him that, if they met with any similar arrangement in nature, they would not be able to detect the fallacy, except by some process of reasoning from analogy. He should advise that these objects be examined by various powers up to $\frac{1}{8}$ inch, and was sure that some very instructive results would follow. With this power they did not get at all a true idea of the object, but they did obtain a still more curious optical puzzle than was the case with the lower powers; in fact, the effect obtained was one which, if it had occurred in any object where there were fibres or striæ crossing each other in a similar way, would easily lead to the true character of such an object being mistaken.

There was one other little matter which he thought it might be of some interest to mention. Among the species of black fungi which were found infesting orange and other trees, and which appeared in great abundance last autumn, one attacked a bay tree or true laurel growing out of doors, and it seemed able to remain and grow upon the leaf for a long time without injuring it. Many of the leaves which he had examined did not seem at all damaged, although the fungi had remained upon them from last autumn to the present time. It was quite easy to take them off with a penknife, and as there was no penetration of the fungus into the structure of the leaf, as soon as the film was removed the leaf seemed all right again. A fungologist to whom he had shown it, thought it to be a species of *Capnodium*. (Drawings of its general appearance were then made upon the black-board.) An interesting physiological question arose in connection with it: What was the good of the plant to the fungus if it did not penetrate the structure of the leaf? The respiration of plants was the same in principle as that of animals, but they were also able to do what animals could not do, and that was to digest carbonic acid. Whether any of the matters exhaled by the leaf were of use to the fungus, he could not say. Specimens of the leaves with fungi upon them were then handed round, in the hope that some gentleman present might be able to identify them.

Mr. Thomas Palmer said he had found a very similar fungus recently upon the leaves of the Arbutus. It did not penetrate the leaf, but was merely a kind of surface fungus, and could be readily brushed off by tolerably stiff bristles. He had, however, observed that when the black mass had been removed, the leaf underneath was of a much lighter colour than the surrounding parts.

The President had found a number of small beads, in irregular grape-like groups, in connection with it, which he thought might possibly be spores.

Mr. Vize said that, without examining the specimens more closely, he could not determine the species; his impression, however, was, that it was an immature form of *Capnodium*, which, as a rule, it was very difficult to find in England in the mature state. Under a bell glass, with sufficient warmth and moisture, they could be got to develop more fully.

The President inquired if Mr. Vize could answer the question, of what special use was the plant to the fungus; what caused it to establish itself there?

Mr. Vize could only suppose that the spores had dropped at some time upon the leaf, and having found a nidus, had there developed. It was well known that the spores were carried about in the air, and that special spores were developed in special positions which happened to favour their habit of growth.

Dr. M. C. Cooke, in reply to a question from the President, said that the drawings made upon the black-board sufficiently convinced him, without looking further at the specimens, that the plant which they had there was one which was common on almost all the hard-leaved shrubs, *Capnodium Footii.* It was the early condition of it, and beyond which it seldom proceeded farther in this country. It consisted chiefly of a pellicle of mycelium, the free cells of which gave rise to the quantity of threads shown. In the fourth volume of the Journal of the Horticultural Society they would find a paper upon the subject by the Rev. J. M. Berkeley and Desmazières, in which it was fully described, and which, he believed, gave rise to the genus *Capnodium*, which at present contained three species, of which this one, *C. Footii*, was the most common. With reference to the pellicle being so easily removed, he had the honour of reading a paper before the Royal Horticultural Society upon this subject, and the conclusion at which he then arrived was that in many cases it appeared that this fungus developed itself upon the honey dew and other secretions upon the surface of the leaf. For instance, the lime tree was well known for the quantity of sweet matter found upon its leaves, and in the autumn it was not unusual to find almost every leaf affected by a black, sooty appearance, which was nothing more nor less than *Capnodium*, and it appeared certain that this fungus drew its nutriment from this secretion of saccharine matter either by some of the Aphis tribe or by the plant itself, without striking at all into the substance of the leaf.

The President felt sure they were all very much obliged to Dr. Cooke for the very interesting remarks which he had made. It showed that if the Fellows of the Society would sometimes mention things which came under their notice, it might, as in the present instance, lead to a very interesting communication from some one present who might be qualified to give them the further information which they required.

The following gentlemen were elected Fellows of the Society:—Mr. Amos Hobson; Mr. George Brook; Mr. G. A. Woods; and Mr. Frank Campion.

Scientific Evening, *May* 15, 1878.

The last scientific evening of the session was held, by kind permission of the authorities, in the libraries of King's College, on the 15th of May. There was a good attendance of the Fellows, and as the subjoined list will show, apparatus and objects of great interest were exhibited. The Society were indebted to Messrs. How and Co. and Mr. Baker for the use of a number of excellent lamps.

List of Objects Exhibited.

Mr. J. Badcock: *Fredericella sultana*, and a supposed new ciliated Infusorian.

Mr. J. W. Bailey: Folding microscope with large stage, and nummulitic limestone.

Mr. Charles Baker: Zeiss' new $\frac{1}{8}$ oil immersion object-glass not requiring correction.

Mr. Thomas Bolton: *Hydatina senta.*

Mr. J. Browning: Stained and injected preparations illustrating the anatomy of the Frog; and a new lantern microscope with oxy-hydrogen light, for use with ordinary objects and slides.

Mr. J. C. Burch: New reflecting micrometer.

Mr. Rochford Connor: A set of beautiful drawings of microscopic objects, comprising Foraminifera, Polycystina, Diatomaceæ, and other objects.

Mr. Frank Crisp: A pair of large Nicol's prisms 12 inches long, with $3\frac{1}{2}$ inches clear field; a set of large quartz crystals $3\frac{1}{4}$ inches over, and other objects for exhibition with the prisms. Made by Mr. Ahrens.

Mr. Thomas Curties: *Lophopus crystallinus;* a selection of the Rev. J. Vize's micro-fungi mounted, and a collection of Professor Cleve's diatom slides.

Mr. F. Enock: Some insect preparations mounted without pressure; tongue of *Cerceris arenaria*, &c.

Mr. F. Fitch: Reproductive organs of *Nomada lineola*, both male and female; a parasitic bee, &c.

Mr. C. J. Fox: Mica combination of twenty-four films, showing by polarized light the first three orders of the Newtonian spectrum, divided into eighths; mica combination of eighty-four films, showing Airy's spirals; and crystals of sulphate of cadmium, with polarizing apparatus rotating by clockwork.

Mr. W. H. Gilburt: Section of yew, *Taxus baccata.*

Dr. W. J. Gray: Fungoid cancer of mamma, double stained by Mr. Cole.

Messrs. How and Co.: Sections of rocks, lherzolite from the Pyrenees, Cornish serpentine, and hornblende schist.

Dr. Millar: Sections of *Acarnus innominatus*, and one showing that the recurved spicules figured by Carter as *Acarnus innominatus is* a distinct sponge.

Mr. A. D. Michael: A new species of *Cheyletus*, proposed to be called *C. flabellifer.*

Mr. Fred. Oxley: A supposed new species of Œcistes.

Mr. B. W. Priest: A sponge, *Halyphysema tumanowiezii.*

Mr. G. P. Price: Some anatomical preparations, injected intestine of rat, duodenum of rat, &c.

Mr. A. Pumphrey exhibited and described his new process of autographic printing, which he illustrated by means of a sketch brought by a Fellow to the meeting.

Messrs. Ross and Co.: New Zentmayer microscope-stand with recent improvements, and Wenham's high-power binocular prism, showing the Podura scale with $\frac{1}{5}$ and $\frac{1}{15}$ object-glass.

Mr. W. W. Reeves: *Callidina* sent up by Lord S. G. Osborne during April, 1873, and kept alive by having water put to them about once in six or seven months.

Mr. H. J. Slack: *Cheyletus eruditus* and other mites.

Mr. James Smith: Specimens of leaves, showing hairs and spines.

Mr. H. C. Sorby: Drawings made with pigments from human hair, one red and the other black.

Mr. Charles Stewart: Sporogonia of *Funaria hygrometrica*, and some new Polyzoa.

Mr. Amos Topping: Various patterns of grouped Polycystina, and some injected preparations mounted in balsam, but preserving the true form as in fluid mounting.

Mr. F. H. Ward: New form of micro-spectroscope; spectrum of didymium, didymium glass, &c.; and sections of the stem of *Eucalyptus* stained with carmine, logwood, &c.

Mr. Robert G. West: Lissajou's curves on glass slides for the microscope.

King's College, London, *June* 5, 1878.

H. J. Slack, Esq., President, in the chair.

The minutes of the preceding meeting were read, and were signed by the President.

A list of the donations received since the last meeting was read by the Secretary, and the thanks of the Society were voted to the respective donors.

The President said that under the old practice of the Society its meetings took place on the second Wednesday in the month; but when the 'Monthly Microscopical Journal' was commenced, it was represented to them by the Publisher that this did not give sufficient time to allow of the 'Proceedings' appearing in the next monthly issue. On this account their night of meeting was altered to the first Wednesday in the month, which had been found to clash with the meetings of the Geological Society and some others, to the great inconvenience of many of the Fellows. Under the new arrangements for the Journal there would be no difficulty in regard to the publication of the 'Proceedings' if their meetings were held later in the month; and it had therefore been suggested that they should revert to the original plan of meeting on the *second* instead of on the *first* Wednesday in the month. Their next meeting would not take place until October, before which time a new list of meetings would be issued, and in which the alteration would appear. It was not quite formal to bring the question before an ordinary meeting, but the Council—with whom it rested to make the change—thought it better to mention it this evening, so that if any Fellow had any objection he might be able to state it. All that the Council wished was to accommodate the greatest number as much as possible.

There being no objection raised, the President formally announced that in future the meetings of the Society would be held on the second Wednesday in each month during the session.

The President said the meeting would be pleased to hear that they were favoured with the presence that evening of Professor Stokes, Sec. R.S., who had come up from Cambridge to read a paper he had prepared on the angular aperture of object-glasses, and which it was considered would entirely dispose of the points formerly in controversy on this question. Before he read it, the Secretary would read a note by Professor Keith, bearing on the same subject.

Mr. Frank Crisp (Secretary) then read the note by Professor Keith, which was entitled "On the Results of a Computation relating to Tolles' $\frac{1}{6}$ Objective." It was accompanied by photographs of the Professor's computation and of his diagram of the objective, showing the lenses of which it was composed and the path of a ray through it.

Professor Stokes, after disclaiming for his paper all the importance attached to it by the President, proceeded to read it with comments, illustrating it by reference to diagrams, and by drawings upon the black-board.

Mr. Ingpen ventured to make a few remarks on the practical bearing of the paper they had just heard. The theory was evidently correct, and would not be doubted by anyone acquainted with the more advanced optics, but there was some practical difficulty in securing an illuminating pencil which could utilize the increased angle of aperture obtained by the new arrangement. This could not be done by any ordinary condenser, where the light impinged upon the under side of a flat surface, but it was effected by Professor Abbe's immersion illuminator, and others constructed on similar principles. Another difficulty—one for the optician—was to construct such middle and back combinations for the objective as would utilize the large cone of rays entering the front hemisphere. This Professor Abbe had certainly achieved to the extent of 113°, which was a great advance on all previous apertures.

Mr. J. W. Stephenson (Treasurer) said it was true that they were limited to an equivalent angle of 180° in air if they had a plane dry surface beneath the slide; to get the full effect they must, of course, have some medium to connect the condenser with the balsamed object instead of air; Professor Abbe had now devised an immersion condenser having a balsam angle of 138°.

Mr. Mayall, jun., said that Professor Abbe had not been the first to devise means of illumination far exceeding the limit that obtains when the base of the slide is flat and dry. A lens almost exactly similar to Professor Abbe's was figured by Mr. Wenham in the 'Quarterly Journal' more than twenty years ago, and the purpose was the same,—to obtain extremely oblique illumination. Mr. Wenham suggested its use with the paraboloid. Then we had the reflex illuminator, that works well up to a moderate limit; the immersion semi-cylinder that permits the rays to fall on the object, when mounted on the slide or in balsam, at an inclination approximating to 90° in glass, and various forms of immersion prisms, among which Dr. Woodward's is particularly practical. He did not understand Mr. Ingpen's difficulty in providing oblique rays of sufficient intensity for practical use, as the difficulty he had found was to regulate the amount of the light, not its obliquity. For example: by blocking out the whole of that part of the illuminating pencil on a balsamed object that corresponds to the air pencil of 180°, and using only rays beyond this inclination, he had found, with objectives having balsam angle of 95° and upwards, the more difficult images were made more appreciable by the eye. It appeared to him it was the excess of angle beyond 82° in glass of the illuminating pencil that enables us to see the more difficult images; and so it is with the aperture of the objective. In the demonstration given by Professor Stokes the object is supposed to be self-luminous, emitting a pencil of rays of 180° in glass, which pencil was shown to pass by a single refraction, without aberration, from the front lens, and to present to the second lens a pencil in air of only just beyond 81°. Professor Stokes did not say the whole of this pencil can be made available in a practical construction, but he stated that a very considerable portion of it—largely in excess of what is available in a dry lens—could be so used. After this demonstration the question of the possibility of immersion lenses having apertures exceeding the maximum possible in dry lenses would be settled from the theoretical point of view. His opinion on the validity of Professor Keith's computation of the aperture of Tolles' $\frac{1}{6}$—Mr. Crisp's lens—must also be conclusive. It remained to endeavour to support the computation by actually measuring the aperture of the lens before the meeting—which he proposed doing, not of course expecting any general agreement at this stage of the discussion as to the least objectionable way of measuring apertures, especially with this individual lens. He would be content to show the measurement by Professor Abbe's apertometer, the results obtained with which he had found to correspond with those obtained by a modification of Professor Robinson's method which was submitted to Professor Stokes, and for the accuracy of which he had his authority. A method was specially commended by Mr. Charles Brooke in one of his Presidential addresses, viz.: to measure the working diameter of the front lens, which is taken as the base line of an isosceles triangle; taking the exact focal distance as the perpendicular, the triangle would represent the angle of aperture. The objection to this method in practice, was that when it was tried with the $\frac{1}{6}$ lens, the data furnished were so various and contradictory that no reliance could be placed on the results: in one case the focal distance being given as 0·13, then ·018; in another ·025,—the working diameter being given first as ·043, then as ·033.

Professor Stokes said that of course it would be understood that, as stated by Mr. Mayall, he confined himself to the consideration of a point as if it were self-luminous, and contemplated that the object was illuminated by immersion; if they let in light to the plane surface in air they would be limited to twice the critical angle.

The President announced that they had received a letter from Professor Abbe, thanking the Society for the honour done to him by his election as an Honorary Fellow of the Society.

Mr. Charles Stewart (Secretary) read a paper by the Rev. W. H. Dallinger, "On the Measurement of the Diameter of the Flagella of *Bacterium termo*, a contribution to the question of the ultimate limits of vision with our present lenses."

The President said that what must have struck everyone who had listened to this paper was the extreme smallness of the objects measured, for if Mr. Dallinger was correct (and there was no reason for doubting his correctness), then it was clear that objects of very much greater minuteness could be rendered visible than had usually been considered possible. These objects were about the smallest which the microscope would show, and yet it appeared that they probably stood higher in the scale of organisms than some other objects which were generally considered to be higher. He thought that these investigations of Mr. Dallinger would tend to raise such objects to a much higher rank than that previously assigned to them.

The President said they had two other papers before them; one of these was from Mr. F. A. Bedwell, "On the Framework of the Mastax of *Melicerta ringens* and *Conochilus*," and the other was a translation by Mr. Kitton of a paper by M. Paul Petit, "On some New Genera and Species of Diatomaceæ." The latter paper was, of course, unsuitable for reading *in extenso*, and would be taken as read. The paper by Mr. Bedwell was of considerable interest, and went into the minute structure of the organ at some length; but in his opinion, apart from the illustrations (which would be handed round), it would scarcely be possible to do full justice to the author or his subject in the time left at their disposal, and it would therefore now be taken as read, and would appear in the Journal together with the illustrations in September. He would also call attention to the extremely good slides of the mastax of *Melicerta* and *Conochilus* made by Lord S. G. Osborne, which had been sent up by Mr. Bedwell for examination by the meeting.

Mr. J. W. Stephenson (Treasurer) read a "Note on the effect produced on *P. angulatum* and other Tests by excluding the central dioptric beam of light," which he explained was accomplished by placing a central stop at the back of the objective, so that the diffraction spectra alone formed the image.

Mr. Frank Crisp (Secretary) said that, in view of the four months' vacation now commencing, he should like to call the attention of the Fellows to the experiments on diatoms immersed in a solution of indigo or other coloured liquid, a note of which had appeared in the last number of the Journal (vol. i. p. 79), and the important conclusions that those experiments pointed to, particularly in regard to the motions of diatoms. The experiments were well worthy of being repeated and confirmed, and if any Fellow during the vacation would be kind enough to do so, he would, no doubt, be able to make a very interesting communication to the Society when they met again.

The President suggested that Professor Stokes should take up the question of the limits of visibility, which in his hands would doubtless receive some important advancement towards a conclusion. He also mentioned that some specimens of drawings reproduced by the autographic process (which was exhibited at their recent scientific evening, by Mr. Pumphrey, of Birmingham) had been sent to the Society for distribution.

At the conclusion of the meeting Mr. Stephenson exhibited *P. angulatum* under the conditions described in his "Note," and with the new oil-immersion lens, using a deep astronomical piece by Dollond, sen. The diatom appeared of a brilliant blue on a perfectly black ground, and the definition left nothing to be desired.

Mr. Mayall, jun., also demonstrated the aperture of Tolles' $\frac{1}{6}$ immersion lens by Professor Abbe's apertometer. He first exhibited the apertometer with Zeiss's new oil-immersion lens, recording a balsam angle greater than 106°; then he showed the aperture of a high-angled dry lens to be within double the critical angle, i. e. less than 82° in glass; then he showed the aperture of Tolles' $\frac{1}{6}$ immersion to be in excess of the limit for dry lenses, i. e. greater than 82° in glass. The demonstration was conducted in the presence of Professor Stokes, Mr. W. G. Lettsom, Mr. J. H. Dallmeyer, Mr. F. Crisp, and others interested in the subject.

The meeting was then adjourned to the 9th October, and the President reminded the Fellows that the library and reading room would as usual be closed during the month of August.

Donations to the Library, &c., since April 3, 1878:

	From
Nature. Weekly	*The Editor.*
Athenæum. Weekly	*Ditto.*
American Journal of Microscopy, March, 1878	*Ditto.*
Society of Arts Journal. Weekly	*Society.*
Quarterly Journal of the Geological Society	*Ditto.*
Bulletin de la Société Royale de Botanique de Belgique	*Ditto.*
Bulletin de la Société Botanique de France	*Ditto.*
Papers and Proceedings of the Royal Society of Tasmania, 1876	*Ditto.*
Transactions of the Watford Natural History Society. Part 9	*Ditto.*
Journal of the Linnean Society: Zoology. No. 74	*Ditto.*
Report and Abstract of Proceedings of the Croydon Microscopical Club, 1877	*Club.*
Mineralogical Magazine	*Society.*
An Old ("Conical") Microscope with Apparatus	*S. S. Wigg, Esq.*

The following gentlemen were elected Fellows of the Society:— Dr. James Edmunds; Major Richard O'Hara.

Walter W. Reeves,
Assist.-Secretary.

JOURNAL

OF THE

ROYAL MICROSCOPICAL SOCIETY.

SEPTEMBER, 1878.

I.—*On the Measurement of the Diameter of the Flagella of Bacterium termo: a Contribution to the Question of the "Ultimate Limit of Vision" with our present Lenses.* By Rev. W. H. Dallinger.

(*Read before the* Royal Microscopical Society, *June* 5, 1878.)

Plates VIII. and IX.

It will be remembered by this Society that two years ago, having in conjunction with Dr. J. J. Drysdale completed as far as we then purposed a series of observations on the life-histories of a group of monads, we determined to use the experience thus gained, and if possible to study in a similar way the Bacteria. We commenced on *B. termo;* and our first object was to make out clearly its normal form, and to discover if possible the agency by which movement was effected.

In the case of the large form known as *Spirillum volutans,*

DESCRIPTION OF PLATES.

Plate VIII.

Fig. 1.—*Bacterium termo* × 4000 diam.
„ 2.—*Spirillum volutans* × 2000 diam.
„ 3.—*Vibrio rugula* × 2000 diam.
„ 4.—*Spirillum undula* × 3000 diam.
„ 5.—*Bacillus ulna* × 3000 diam.

Plate IX.

Fig. 6.—*Bacterium lineola* × 3000 diam.
„ 7.—Photograph of *Bacillus subtilis*, showing flagella. By Dr. Koch × 500.
„ 8.—Ditto, ditto (or as Dr. Koch thinks a variety, *B. amylobacter*), also photographed, and faintly showing flagella × 700 diam.
Fig. 9.—*Bacillus subtilis* × 4000 diam.
„ 10.—*B. termo.*
„ 11.—A camera lucida outline of the lower part of *B. termo*, magnified 2000 diam. *c* is the pencil line intended to cover the image of a part of the flagellum; and *a* represents by dots the part of the image with which the line can be compared.

Fig. 12 is the above drawing placed on the stage of the microscope, and magnified 5 diam. In this way the ratio between the diameter of the body of the Bacterium and the diameter of the flagellum can be compared by means of the wires of a screw micrometer. The ratio here shown being as 10 to 1.

Cohn had demonstrated, what Ehrenberg had suspected, and we had readily confirmed, that its movements were produced and controlled by a pair of fine flagella, one at each end of its spiral body. This was extremely suggestive: while we had further the analogy of the minuter monads, many of them being only four or five times larger than the larger forms of *B. termo*—these also being endowed with one or more flagella, suggesting the probability that all these forms depended for movement on similar motile filaments.

We therefore determined to endeavour to discover whether, by care and delicate manipulation, flagella could be demonstrated on *B. termo* itself.

Fortunately at this time we were furnished with a "new formula" lens, which possessed precisely the qualities needed. Carrying out our method of admitting nothing, in our conjoint work, which both had not seen, I commenced the search; and after many hours' effort, and the use of a great variety of delicate appliances, I succeeded in clearly demonstrating a pair of flagella, one at each end of the body of *B. termo*, without the shadow of a question. Dr. Drysdale now, independently, commenced the search, simply employing the same methods, and ultimately demonstrated it as completely as could be desired. We were then able to study it together, seeing the delicate fibre as distinctly as the body of the *B. termo* itself, and I made careful drawings from this, which Dr. Drysdale accepted and confirmed.*

Most of the forms at present grouped as Bacteria vary, very considerably, in size. Some, for example, that may be designated *B. termo* will be as large again as others; and this is the case throughout, only that the variation will be still greater in those forms which, instead of dividing into two parts, divide into several. There is for instance very great variety in the length of *S. volutans*. But the average length of *B. termo*, resulting from a hundred measurements made from this form as taken from six different infusions, was the $\frac{1}{10000}$th of an inch. The average of one hundred measurements of *S. volutans* (taken only from one infusion) was the $\frac{1}{1000}$th of an inch, but these were large. In Fig. 2, Plate VIII., I give a drawing of a recent specimen of *S. volutans* magnified 2000 diameters; and at Fig. 1 a *B. termo* is placed beside it, as it was seen by Dr. Drysdale and myself, magnified 4000 diameters.

Since this account of the discovery of flagella on *B. termo* was published, several valuable monographs have appeared on the subject of Bacteria. From the point of view I am now specially considering one of the most interesting and valuable is by Dr. Eug. Warming.† In it he points out that the flagella are common to the

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* 'Monthly Microscopical Journal,' vol. xiv. p. 105.

† 'Om nogle ved Danmarks Kyster levende Bakterier.' Kjöbenhavn, 1876.

group, and that in some cases they have two flagella at one end, a fact which I have frequently confirmed. But there is an immense difference between all the other forms and *B. termo*, in size. It may be helpful to realize what this difference is: and I have given copies of drawings from nature of all that Warming and others give as possessing motile filaments, which I have been able to confirm. They are each magnified as indicated, either to the same extent as *B. termo*, or to two-thirds or a half that extent. *Bacillus ulna* and *Bact. lineola* (Figs. 5 and 6) I have not hitherto seen as included in the list of those possessing flagella; but they are given as drawn by camera lucida from nature during my investigations for this paper. Their flagella are certainly not more difficult to demonstrate than the flagellum of the uniflagellate monad whose history was studied and described by Dr. Drysdale and myself in January 1874.* A comparison then of Figs. 2, 3, 4, 5, and 6 with Fig. 1 will indicate as accurately as may be the relative sizes of the varieties now known to be possessed of flagella, when compared with *B. termo.*

But a still more instructive instance is before me. Dr. Koch, in a paper recently published † has given illustrations taken by *micro-photography*, of what he considers to be *Bacillus subtilis* (or a variety), in which the flagella are distinctly visible in the print. I send these photographs, which can doubtless be reproduced by lithography. In Fig. 7, Plate IX., the magnifying power is 500 diameters, and the flagella are distinctly visible. In Fig. 8 the magnification is 700 diameters, and the form shown at *a* displays what are doubtless its flagella, although they are but feebly and faintly manifest. These photographs were, however, not taken while the organisms were living, nor in their natural fluid. They were, indeed, specially prepared, by drying, staining, and mounting in glycerine; and then photographed. This must to a certain extent superinduce change of condition, and even alteration of form. This is manifest in the relative thickness of the flagella and the bodies of the forms photographed, which is certainly not in all cases as it presents itself in the living organism; this is specially seen in Fig. 7. But the wonder is that they are so successfully, and even beautifully done. In Fig. 9 I give a drawing from nature of *B. subtilis* magnified 4000 diameters, to show at once, the relation of this form as a "species" to *B. termo*, and to show the condition in which those must have been which Dr. Koch photographed; namely, the separated segments, such as *a, b*, which become provided, like *B. termo*, with flagella, as they divide.

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* 'M. M. J.,' vol. xi. p. 69.

† 'Verfahren zur Untersuchung, zum conserviren und Photographiren der Bacterien,' Von Dr. Koch. Beitrage zur Biologie der Pflanzen. Edited by Dr. F. Cohn. Third part, 1877.

Dr. Koch has never seen the flagella in *B. termo*, but he has made no effort to do so, because, as he tells us, he used low-angled glasses which are incompetent to the demonstration; and has made no special provision for illumination, without which it is utterly impossible to see this fine organic fibre. Dr. Koch too, by using a method in which drying, staining, and mounting are involved, is, I am inclined to think, making the demonstration more difficult. He, however, without having made any effort to discover it, has no doubt that the discovery of it is a demonstration in the proper sense, although extremely difficult to make; and he believes that the entire group of motile Bacteria are endowed with flagella.

There is not the slightest doubt that this inference is correct.

In all extremely delicate work with high-power lenses, the first difficulty is the greatest. If once an object has been seen, however difficult, it is immensely easier to see it again. On the other hand, I have learned from experience that there is as great a diversity in different individuals in the sensitiveness of the retina, as there is in sensitiveness of the olfactory or auditory nerves. It is impossible to enable some persons to see objects beyond a certain limit of minuteness; as it is to enable others to detect certain scents, or hear notes pitched higher or lower than a given point. This is illustrated by the telescope as well as by the microscope, and has application to the practised as well as the casual observer. It is therefore fortunate that the constantly accumulating refinements of photography will ultimately provide us with a film equal to—perhaps finer than—the most sensitive human retina in its powers to fix the minutiæ of detail, in form and structure, revealed by our highest powers and best lenses. But even then the efficiency of the results will be influenced by the delicacy of the retina, and the perfection of the eye of the manipulator.

In the matter of the delicate flagella of *B. termo* the great difficulty had been overcome; and for some time subsequently there was considerable fascination, in spite of the great difficulty, in repeating again and again the observation. At first we could only get the result with the "supplementary stage" illumination referred to in our joint paper. Since, however, I have succeeded with Powell and Lealand's sub-stage condenser, and with Wenham's reflex illuminator, using with this last apparatus, glycerine, between the prism and the under side of the glass slip.

The secret of success, skilful manipulation and the right kind of lens being assumed, is the manner in which the Bacteria are prepared. They should be taken from an old and thick maceration; not a recent infusion with a thin fluid; and then should be very gradually accustomed to thinner and thinner fluid, until, by two or three days' habituation in Cohn's fluid, for a few hours they will live in *water*. And it is in this that they should be examined;

for the comparative opacity of the natural fluid makes it impossible to see the flagella, and in the water there is obviously a greater contrast between it and the sarcode of the flagella, than there is in the thick decomposing fluid. And I have repeatedly observed that if the Bacteria are taken from a recent infusion which is little more in substance than water,—probably from some difference in the density of the sarcode,—the flagella cannot be discovered.

After repeatedly, and in different ways, having demonstrated the flagella, it struck me that much would be gained if it were possible to *measure* its diameter. To do this by a direct method was impossible with any instrument with which I am acquainted; but it might, it appeared to me, be done with very approximate accuracy by an indirect method. To this end I made a series of investigations with Powell and Lealand's "new formula" $\frac{1}{8}$ objective, and with what appeared to me extremely interesting results. But subsequently they furnished me their $\frac{1}{12}$ and $\frac{1}{16}$ inch lenses on the same formula. And as immersion lenses their performance is remarkably beautiful. I also had a very fine immersion $\frac{1}{25}$ by the same makers; and at my request they made me a $\frac{1}{35}$, the first they had ever made. This lens was made with a view to the special class of observations in which I have been engaged, and it is an extremely beautiful one. The angle is moderate, and the lens with the same front is both immersion and dry. Its definition when properly used is very crisp and clear, and its "penetration," considering its magnifying power, is very considerable.

My purpose was, having been furnished with these lenses, to make a series of indirect measurements with each of these lenses separately, and then compare the results and obtain an average.

My method was as follows, viz.:—

1. It was necessary, and comparatively easy, to measure accurately the absolute diameter of the Bacterium body, as, for example, in Fig. 10, Plate IX., to find the actual distance from *x* to *y*.

2. Next it was needful to make a very careful camera lucida drawing of the body and a part of one of the flagella. The microscope being in an upright position the ordinary camera lucida cannot conveniently be used; but an extremely useful instrument, made by M. Nachet, of Paris, to meet this emergency, answers admirably. It is, indeed, much easier to draw with than the ordinary camera lucida; and in using it with high powers all that is required is, that the right hand employed in drawing be *illuminated* a little more intensely than the "field," when it will appear extremely "ghostly," but very sharp and clear, and the pencil point is admirably defined.

A fine white surface is needed which will receive a mark without such rough edges as are made, with even very hard pencils, on the finest London or Bristol cardboard. That which I find to answer best, is the "enamelled cards" which are used by the printers for visiting cards. I also use a H H H H, Windsor and Newton or Faber pencil (with the wood cut considerably away in the former, the latter being obtainable in solid cylinders, which are slid into holders), which is brought to its final point by gentle rubbing on the surface of the finest ground glass, or, better still, a very fine hone. With these appliances a drawing was made, first, of the lower half of the body of the *B. termo*, and then, which was the really critical matter, a pencil mark was made over a half or two-thirds of the flagellum, not over the whole; for in this way the flagellum image and the pencil mark could be carefully compared, as shown at Fig. 11, where the dotted part *a* represents the image of the flagellum as seen beyond the pencil line *c*; and a very close approximation may thus be made between them.

Having determined that the pencil mark, as at *c*, Fig. 11, accurately corresponded to the image of the flagellum, this drawing was taken and magnified from five to ten diameters, the amount of magnification being accurately determined beforehand. By this means it was easy to determine the *ratio* existing between the now measurable diameter of the pencil line representing the flagellum and the *diameter of the body*. But this latter was a known quantity; and therefore it was easy to determine the actual diameter of the flagellum. Thus at *b*, Fig. 11, there is an outline camera drawing of the lower half of a *B. termo* magnified 2000 diameters. *c* is the pencil line corresponding to a part of the flagellum, the dotted line *a* representing the remainder, with which the pencil line could be compared. At Fig. 12 we have the same drawing *magnified* five diameters; and in this condition it is quite easy by means of the "screw micrometer" to find the *ratio* existing between the magnified image of the drawing of the body and that of the flagellum. In other words, it is soon seen how many flagellum spaces are needed to cover the diameter of the body. In the case before us, the bacterium drawn at Fig. 11 had a diameter of $\frac{1}{20400}$th of an inch. The ratio of the flagellum to the body, as seen in Fig. 12, is as 10 to 1; and $\frac{1}{20400} \div 10 = \frac{1}{204000}$th of an inch, the actual size of the flagellum.

Now I made fifty separate drawings and measurements with each of the four lenses; the same conditions being observed in each case. The results expressed in decimal fractions are as follow, viz.:—

(1) The mean value of fifty measurements made with the $\frac{1}{12}$th inch objective, gives for the diameter of the flagellum 0·00000489208.

(2) The mean value of fifty measurements made with the $\frac{1}{16}$th inch objective gives 0·00000488673.

(3) The mean value of fifty measurements made with the $\frac{1}{25}$th inch objective gives 0·00000488024.

(4) The mean value of fifty measurements made with the $\frac{1}{35}$th inch objective gives 0·00000488200.

We thus obtain a mean from the whole four sets of measurements, which gives for the value of the diameter of the flagellum of *B. termo* 0·00000488526, which expressed in vulgar fractions is equivalent to $\frac{1}{204700}$th of an inch nearly; that is to say, within a wholly inappreciable quantity.

Now if we suppose that as the method is only an approximate one, and the errors are entirely on one side, which I know no reason for doing, and therefore in round numbers reduce this fraction to the $\frac{1}{200000}$th of an inch, it nevertheless provides us with a fact of much interest; and indicates, as I believe, that an atom of semi-*transparent* structure the $\frac{1}{200000}$th of an inch may become visible under proper conditions of illumination and general manipulation. How far this is the actual limit with transparent or nearly transparent objects, I will not venture to affirm. But I am inclined to believe that it comes very near to it. But why, whether from the limitations involved in the nature of the luminiferous æther, and the conditions of light vibrations, it is not my province to pronounce.

The calculations of which this paper gives the results have been carefully revised by my friend Mr. C. H. Stearn, of Liverpool.

II.—*The Mastax-Framework in Melicerta ringens and Conochilus, described by* F. A. Bedwell; *with further Notes on these Rotifers.*

(*Read before the* Royal Microscopical Society, *June* 5, 1878.)

Plates X. and XI.

Lord Sydney Godolphin Osborne, in January last, entrusted to me the agreeable duty of describing the mastax of *M. ringens* from a series of slides of that organ as dissected by him from the rotifer itself, and mounted. I must premise that it is quite impossible for me to hope to do justice to the great beauty of the contents of these slides, either by pen or pencil, they must be seen to be enjoyed; the accompanying drawings simply express diagrammati-

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DESCRIPTION OF PLATES.

Plate X.

Fig. 1.—Details of framework of mastax of *M. ringens* diagrammatically treated. *a*, *b*, *c*, form the *ramus: a*, *frontal* blade; *b*, *central* blade; *c*, *alula. d d*, *manubria. e e* are rigid attachments, which in life are connected with the angles *c c* of each *alula*, and by lifting the *alulæ* they force *up* the free edge *b b* of the central blade of the *ramus*, and bring *down* the turreted edge of the frontal blade of the *ramus*. *f* is the *fulcrum*, the hinge, confused by flattening, see Fig. 6. *p p* are the teeth, fifteen in number, removed from their supports; in nature they lie with their points fixed in the turreted serrations of the frontal blade of the *ramus*, their roots being attached to the *manubria*, along the lines *g h*.

Fig. 2.—The letters repeated. This figure represents the free edge of the *ramus*, lifting up to the under side of the teeth, and bending them towards the rectangular position which they are seen to possess in life when masticating food. (Five of the teeth have been removed.)

Fig. 3.—Explained in text.

Fig. 4.—A mechanical illustration of the *ramus*, to be cut out in cardboard, and explained in the text.

Fig. 5.—One of the large teeth.

Plate XI.

Fig. 6.—This diagram represents the hinge *fulcrum* and the two *rami* of *Conochilus volvox*. The letters refer to the same parts as in *M. ringens;* the points *c* and *e* are united in life, as also are those parts at K and H which have been separated in the diagram.

Fig. 7.—This figure is explained in the text, and represents the hinges H and K when the organ is at work, and shows how the arms of the *ramus* springing from K meet together, and how the arms that drive the *alulæ* rise upwards at H, and so lift up the *alulæ*.

Figs. 8, 9, 10, are transverse imaginary sections of the mastax, and show how, as the end of the *alula c* is lifted *upwards*, the points of the teeth tend to come *downwards*.

Fig. 11 is a transverse section showing an abnormal position, explained in the text and seen by the writer, and arising from the *manubria d*, giving their forward blow along the teeth at a moment when the *alulæ c* were not lifting the points *b* upwards, so that the teeth bent the wrong way at the points *p*.

Fig. 12.—The eye of Conochilus.

Fig. 13.—Corrected diagrammatic representation of wheel of Conochilus, showing its relation to the sinus into which the food flows on its way to the mastax.

cally the conclusions deduced by me from a careful study of the astonishing characteristics of the apparatus. I have since corrected these conclusions by references to living objects, but I shall begin my observations by confining them at first to the uncorrected impressions made on the eye and mind by Lord Sydney G. Osborne's slides themselves, and introduce the corrected impressions subsequently, for, I think that a principle of observation of considerable importance will be well illustrated by so doing.

The information to be obtained from these specimens supplements in several interesting particulars the previous papers on the same subject noted below, and especially Mr. Gosse's well-known and important paper * on the manducatory organs of the *Rotifera*. A reference to that highly original paper will show the extraordinary variations discovered by him in the organ in the different sections of the Rotifer family, and also the names which he has chosen for the different parts of the organ. The organs are symmetrical and bilateral, and consist of a pair of jaws. The teeth (*unci*) work horizontally, and are forced forward from behind by handles (*manubria*), to which their roots are attached; these *manubria* are armed sometimes with mallet heads (*mallei*), the same teeth (*unci*) are also attached at their points to blades (*rami*), and these *rami* draw the two sets of teeth by the points together, and themselves meet or cross each other at one extremity in a hinge (*fulcrum*), which gives them a scissor or tongs-like action, and in some cases the teeth work on an anvil (*incus*).

Of the figures which accompany this paper, Fig. 1, Plate X., is an anatomical diagram of the parts of the mastax of *M. ringens*. The teeth (*unci*), which I make out to be about fifteen in number, are seen below, at *p p*, having been removed from each jaw; their points of junction with their late supports are expressed in the ease of each *ramus* by the serrated or turreted edges of that organ; these serrations in the diagram represent true sockets visible under a high power, particularly in the case of the large teeth after the removal of the teeth from the *ramus*.† The basket-like organs *d d* are the *manubria*, the parts *a b c* form the *rami*, *f* is the hinge, and the parts *e* will be explained subsequently. Fig. 2, Plate X., is a rough sketch of the general effect of the organ as seen looking towards the hinge, five of the teeth on each side having been removed to make the under parts visible.

Passing on to Fig. 4, Plate X., that figure affords a mechanical illustration to express in cardboard my views of the form of the *ramus*, and I will proceed to explain it. Take a thick piece of cardboard and cut from it a portion with an

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* See Williamson on *M. ringens*, 'Quar. Journal Mic. Sci.,' vol. i. p. 3, 1853; Gosse on *M. ringens*, idem, p. 71; 'Phil. Trans.,' 1856, vol. cxlvi. p. 419.

† In *Rotifer vulgaris* these serrations are very distinct.

outline as in the Figure 4, Plate X., notching the edge as in the figure, then fold the cardboard at the broken dotted line and turn the serrated edge upwards, and make the plane that carries that edge stand up perpendicularly from the plane to which it is attached. Double down the triangular projection E F G, and make it curl downwards and underneath the plane to which it is attached, then bend the handle, and you have, according to the view I take of it, a model of the *ramus* of the right-hand jaw, and a similar course will bring out the *ramus* of the left jaw. We thus have in the *ramus* a handle with two blades or leaflets and a triangular projection. Of these two blades I will, for the purpose of this essay, call the serrated blade the *frontal* blade, and the other the *central* blade, and keeping this mechanical picture in view, we will next consider its mode of action.

The teeth (*unci*) are treated in Fig. 1, Plate X., as if they were fifteen separate teeth, but I feel satisfied that the fifteen are connected with each other by a membrane of some kind, and with this view Lord Sydney G. Osborne agrees. It is exceedingly delicate, but it throws up a soft pink hue whenever a strong concentrated flood of light, taken from the centre of the bull's-eye condenser, is sent through it. It is well known to all observers of this rotifer, that the teeth of *M. ringens*, when in action, are bent like the closed knuckles, and we have, in fact, only to roll the knuckles, when closed, against each other, to obtain a practical illustration of the action of the jaws in the course of grinding food. In these slides, however, the teeth, as a rule, are very seldom bent, but lie flat or are slightly curved, and are seen on inspection to be flattened, watchspring-like weapons. Of these the two largest on each jaw show a central prominent line, see Fig. 5, Plate X. But though, as I have said, in the majority of the slides the teeth lie nearly flat, yet in a few of the slides, and particularly where the mastax is seen to be closed, they are found to be bent into the knuckle-like, rectangular appearance which they have in life, and the mechanical action by which this change is produced, from the flat to the rectangular view, is a most interesting subject, and one requiring careful attention, and I make it out to be as follows:—Suppose the handle of each *ramus* to move on the hinge (*f*), so that the *frontal* blades are made to approach each other face to face, and the teeth brought point to point; now, if the free edge of the central blade keeps tilting upwards until it touches the under side of the teeth, then, as it travels onwards and upwards it will bend the teeth from beneath into an obtuse-angled attitude, and forcing forward, it will gradually reduce this angle to a right angle, and having done this, the teeth of each jaw will then meet in two right angles and form the letter T,—thus, ⅂Γ. The Fig. 2, Plate X., shows the central blade of each *ramus* in the act of working forward and throwing the teeth into this attitude. Now, to the part played in this process by the triangular projection attached to the central blade and hanging down from it, I must call particular attention. I was very much puzzled by its presence in the slides, for it is a most prominent object, and in considering the purpose for which it could possibly be wanted, and with nothing but the slides to go by, I ventured, having no other assistance at hand to guide me, to assume quite tentatively a somewhat old-fashioned principle, and one now falling into disfavour—nay, disgrace, in many quarters—namely, the principle of contrivance,—of adaptation of means to ends, and those means the best means under the circumstances. I ventured, without going so far as to conjecture that Melicerta or her ancestors had taken any part in the matter of supplying their own wants, to assume that what she did want was a power acting at the extreme free edge of the central blade, and operating in such a way as to force that free edge alternately up to and away from the under side of the teeth. Now, if for a moment we consider the bent lever P Q R, Fig. 3, Plate X., and suppose that while the point Q remains at rest the lever has to be moved against an obstruction at R into the position *p* Q *r*, then one of the modes of doing it, under the exigencies of the present instrument, will be to add a bent arm R T, and drag T by a muscle as from a point S. True, the arm R T might be straight; but by rounding it you improve the direction, and you increase the continuance of your strain up to the very last moment, and even at the last moment you leave the strain unexhausted. I therefore fixed upon the corner of the triangle as the point of attachment for the force which lifts up the free edge of the central blade of the ramus, and so bends the teeth. Now it will be observed that all this was entirely hypothetical on my part; but on turning to Mr. Gosse's admirable paper in the 'Philosophical Transactions,' above referred to, I found that in the series of similar organs there reported on by him he identifies in several instances a projection from the *ramus* analogous to the triangular prominence in question, and he gives the organs the distinct name of "the little wings"—*alulæ*. Now, when Mr. Gosse saw the organs, many of the muscles were still attached; and amongst others, he says, he found muscles attached to the angles of these *alulæ*. In the specimens before me there were no muscles preserved that I could make out, and when I made my hypothesis I had never even seen Mr. Gosse's paper; but presuming him right, then I had assumed a principle and found a fact. Deductions of this sort may or may not be satisfactory to all minds—may not always be correct, and may be carried too far; but nevertheless they are still intensely fascinating and valuable to the minds of some observers, and amongst others, to that of the writer.

Thus far we have dealt entirely with Lord S. G. Osborne's slides; but the subject receives remarkable and striking illustration on the point at which we have now arrived, if we pass on to the mastax of the living Conochilus. In the slides of *M. ringens*, the hinge is hopelessly confused by flattening, and I confess I could make nothing of it; but good fortune brought me a rich supply of Conochilus in February, and as the same organ in that rotifer is almost identical with that of Melicerta, a description of the action of its parts will be found of great value in enabling us to grasp the whole subject.

Even with Mr. Gosse's paper on the mastax of rotifers to help us, the living Conochilus in action, transparent as it is, forms a hard puzzle to the eye of the observer. But a familiarity with Lord Sydney G. Osborne's slides at once makes its investigation comparatively easy. There is but one position which Conochilus can take that will give a comprehensive view of the more important details of the organ, and unfortunately the animal rarely assumes it, and it requires patience to wait for it, but after close attention I have made out the characteristics of the organ to be as follows. The aspect of the teeth (*unci*), attached by their points to the *rami*, and by their roots to baskets (*manubria*), is exactly like that of *M. ringens;* one picture, in fact, does for both. The teeth are quite straight, they lie very near together, like ridges of plaited paper; there are five larger teeth on each side as against three in *M. ringens.* The number of teeth, fifteen to eighteen, is about the same for each rotifer, and they are connected by a delicate membrane. The *alulæ* are there in striking distinctness, and whenever the mastax is viewed sideways, they are seen hanging down underneath very clearly and in broad, strong outlines. Plate XI., Fig. 6, gives a mechanical drawing of the *rami*, and the *alulæ*, and the hinge, but the teeth and the baskets have all been removed. The plan of construction of each *ramus* will be seen to be much the same as that of *M. ringens.* There is what I have called a *frontal* blade, which carries the points of the teeth, but at one end it is so depressed and insignificant that it really hardly deserves the name of a distinct blade, and I doubt if it is more at the lower end of it than a thickening of the straight edge of the central blade of the *ramus.* At the point, however, where it rises up and leaves the edge of the *ramus,* and just where the large teeth are carried, it appears of a distinctive character. I have made a few turreted spaces in the edge to show where the points of the teeth are carried, and I may add that I have seen the edge actually serrated at that place and in more than one specimen. From the free edge of the central blade, just as in *M. ringens,* the *alulæ* are seen hanging down and curling under the *ramus* and towards each other. With respect to the left-hand *ramus,* I have represented its *alula* by dotted lines where it passes beneath the central blade. In nature this blade is quite transparent, and the *alulæ* can nearly always be seen by focussing through. Facing the lowest angle of each *alula* at the point *c*, will be seen the extremity of a circular arm, *e*, and this extremity in life is rigidly joined to the *alulæ* at the point *c*, where I have severed them. These two circular arms spring from a hinge, H, where I have, for distinctness, again separated parts which in nature are joined; from that hinge springs upwards a handle which is articulated to the two circular arms, and starts backwards and upwards, just as the armed prong of a spur starts from the horseshoe-like arms which pin the spur to the heel. The handles of the *ramus* are seen above, meeting together at a second hinge, K, where they coalesce and bend down to meet the point of the spur as it rises upwards. The hinges H and K in the living animal are imbedded in the large globular mass of muscle which occupies this part of the mastax, and are consequently difficult to decipher.

When the jaws are in action the two handles of the *ramus* spring together sharply at the hinge K, and this action brings the frontal blade of each *ramus* into contact, and so brings the teeth together, but it brings them together *point to point.* But *point to point* is useless to the animal, and it is necessary that the teeth should be tilted up from behind, and their points depressed, so that the upper surfaces of the teeth may grind on each other, like a knuckle on a knuckle, and so that the prominent projecting surface edges of the teeth in one jaw may fit into the depressions which lie between the teeth in the other, like a series of WW^s, meeting each other, angle to angle. It is here that the action of the *alulæ* begins, and a little consideration of Fig. 6 shows that if the angle *c* of each *alula* is raised upwards ever so little, while the main handles of the *rami* are kept closed and pressing against each other, then the free edge of the central blade of the *ramus* must go up, while the points of the teeth must come down.

Now, in action the point of each *alula* is in fact thus raised, and it is elevated by the circular arm *e e* of the spur to which in life it is attached at the point *c*, and from which I have severed it; and these arms, by moving upwards on the hinge H, tend to rise out of a horizontal plane into a perpendicular plane and to take up the position seen in Fig. 7, which is an extreme view of this elevated attitude. As already mentioned, I had anticipated, from what Mr. Gosse said of muscles attached to *alulæ* in other rotifers, that we should find in Conochilus and *M. ringens* a *dragging* force acting by muscles at the angles of the *alulæ* (see Fig. 3, Plate X.), instead of which it is simply a *pushing* force! I did make a mistake in my deduction, but it was one of a most satisfactory character.

The action of the *alulæ* will be further appreciated by an inspection of Figs. 8, 9, and 10. These are imaginary transverse sections across the mastax, and they show how, as an upward force is applied to the *alulæ* at *c* (the points of the teeth being kept together), the free edge of the central blade must gradually work upwards, and the points of the teeth which are rigidly connected with it must come down.

Passing now to the *manubria*, we find that they also are sources of very active power, and though they cannot turn the points of the teeth down, yet they give a sharp push, almost like an impatient blow, longitudinally along the teeth from behind, and thus tend to grind more closely against each other the surface ridges of the teeth, already bent by the *alulæ* into a bowed form. This same push of the *manubria*, indeed, has sometimes a most remarkable effect, for I have witnessed it when it has come too soon, and has therefore actually bent the teeth *the wrong way!* This is shown in Fig. 11, where the depression in the centre of the teeth and on each side at (*p*) is due to the fact that at the moment in question the *alulæ* were not being lifted up, and as the force proceeding from the *manubria* thus acted in a perfectly straight direction, it met with a reaction, because the teeth were point to point, and so the teeth curved the wrong way; and thus abnormally the very contingency arose, which by introduction of the power at the end of the *alulæ* is as a rule prevented. I may add that Mr. Gosse has already dealt with the action of the *manubria* in other rotifers (*l. c.*).

Now I do not know how it may strike others, but to me this mechanism is simply exquisite. We have three distinct lines of power, all at work and in *rotation.* In the first place there is a power at hinge K, then follows the power at hinge H, and then lastly comes that of the *manubria;* the moment the main upper handles of the *ramus* get together, then, and not before, up go the *alulæ* and down go the points of the teeth; the slightest touch does it, and then the *manubria* come in from behind with their crushing force. The hinge H possesses a very distinct power of gaping widely open to take in a large body, and the hinge K shares this power, though hardly, I think, to the same extent. As a whol,e I should describe the organ as a marvellous machine, exceedingly economical of power, and arriving at the best results with very simple and delightfully ingenious means. I am unable to identify any particular muscles—indeed I doubt their existence as separate cord-like attachments—I only saw the movements of the parts, but not what produced those movements; my belief is, that the spherical bodies which support and enclose the principal parts are themselves highly sensitive and contractile.

The examination of the living Conochilus thus quite confirms me in the *a priori* views which I have already expressed in this essay as to the method in which the mastax of Melicerta obtains its rectangular aspect, and which views I derived solely from Lord Sydney G. Osborne's slides, and I must still attribute that aspect to the pressure of the free edge of what I have called the central blade of the *ramus* acting on the under side of the teeth, that free edge being forced up by the pressure on the *alulæ*. A fact to be borne in mind is, that in the dead Conochilus and *Melicerta ringens* pressure usually severs the *alulæ* from the propelling arms of the spur at the point *c*, where I have severed them in the drawings, and the consequence is that in all the mounted specimens there is little to indicate at these angles any solid attachment to the *alulæ* or the existence of a propelling force in connection with them. In some specimens of Melicerta, however, from Redditch, Lord S. G. Osborne has sent me mountings in which I think this connection is sustained; these Melicerta from Redditch are also remarkable for Mr. Slack's conical pellets; some are actually true cones, and others are so long that they are more like ninepins than rifle bullets; they are also remarkable for javelin-headed teeth.

To make out the points here detailed in Conochilus I found it necessary to study it alive and dead. It is a most convenient animal to manipulate, it cannot get away, and it gives you ten or more specimens in each group,* in various attitudes. You must gently clean it from debris with two fine needles. Dead specimens should be treated as suggested by Mr. Gosse in his paper (*l. c.*) with potash and water; with some specimens half and half is too strong, with some it is not strong enough.

As mentioned by Mr. Davis,† the red spots (two in number) are in Conochilus most remarkable organs; each has a highly refractive hemisphere resting on the flat red disk, and apparently partially sunk into it; as Mr. Davis has not drawn it, I have done so (see Fig. 12). The young female Conochilus is born alive; the jaws work in its mother's womb. It comes into the world with a lump of transparent jelly attached to its foot, which goes to augment the globular store of material which is the pedestal or home of the colony.

Everyone must agree with Mr. Davis in thinking that the disk of Conochilus is a very strange apparent departure from the ordinary run of rotifer disks. I give a diagrammatic form, Fig. 13, of the disk, which is corrected from that given by me in the eighteenth vol. of the 'M. M. J.,' p. 214, in which I made an

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* The method I adopted with both Melicerta and Conochilus was to lay them under a piece of microscopic glass on a plain slide, with a very little cotton wool to ease the pressure. Under a low power I then pressed them until the mastax was separated or in the right position; then by adding the liquor potassæ stronger and stronger (and capillary attraction with blotting paper draws it under the glass), the body of the animal is dissolved and the mastax left free for examination under high power.

† 'M. M. J.,' vol. xvi. p. 1.

error, for I treated the disk as continuous all round the sinus; and if, as Mr. Davis suggests in his paper, development from some other form is to be accepted as the mode in which Conochilus attained its present appearance, then I should offer the following suggestion, namely, that in endeavouring to arrange its disk to the best advantage for picking up trifles in a crowd of fellow-creatures grouped in a spherical form, it found it necessary to arrange the collecting cilia *round* the *sinus;* and to do this, it tilted the disk and brought the lower points of the ciliary lobes like a collar forward and round its neck—just as if a sailor were to cut a large slit in his tarpaulin hat behind, at the lower edge, and then draw the two cut corners round his neck, so as nearly to meet under his chin, and keeping the hat on the back of his head, proceed to turn his face upwards (see Fig. 13). The incision under the *calcars* suggests where these two points of the disk may have come from. At the same time, and though I know that I am in a small minority, yet I confess I cannot see how evolution helps us in the least with such an animal; because the moment you suggest a previous form, you ask, Where is it? and I should not like to point to any rotifer sufficiently near Conochilus to justify one in looking upon it as a predecessor in title. To me, the whole rotifer world, in fact, is a wild collection of puzzling forms. There is plenty of likeness and mixture, but there are no links that I can see. There are many forms that make you think of another, but which, when closely examined, range away widely from it in some important particular. To me, the rotifers have, in fact, ever been, and are, a stumbling-block in the way of accepting the development theory as the complete and vast agency that so many now consider it, and the manducatory organs seem to me to deserve close consideration in connection with the subject. If anywhere, I should have expected to find in the rotifer world confirmation strong of the theory — gradations and links in perfect order—classification easy and systematic; instead of which there would seem to be some other principle at work there which runs quite athwart any notion of regularity, which baffles every scheme of classification, and exhibits most unexpected complications—striking gaps where we are led to expect continuity. I cannot help anticipating that the time may come when these very same gaps, existing as they do throughout the animal kingdom, will be recognized by scientific observers exactly as the irregularities of Uranus were fixed upon by Adams and Leverrier, and accepted as indicating *another and an outer force.* As long as this view is overlooked, so long will science be retarded; for what we forget we fail to seek for; and we are apt to stop gaps with great names. We want a principle in direct relation to these regularly recurring *hiati*—a principle which, accepting the fact that the disappearance or degradation of some forms is, as a rule, followed sooner or later by the appearance of new and higher ones, directly accounts for it, and it may be, by directly connecting together the degradation of the old and the appearance of the new. We want a principle that would lift us out of the utter confusion of mind which we are in, when we find that a vast concourse of forms, which we are told reached their present conditions by a process of alteration so gradual as to be almost or absolutely imperceptible—by a continuity of progress requiring a gigantic amount of time for its execution—is yet more especially remarkable for a succession of violent, irreconcilable gaps, occurring too at the very places where we want and are led to expect links. We need a principle in direct relation to the extraordinary gradations upwards and endless varieties of results now seen in the procreative act.—The question is not, *can* evolution make the mastax of *M. ringens?* but, *has* it done so? A great geological professor derived *teapot* from *tepeo,* to be warm, but he still left a better derivation possible.*

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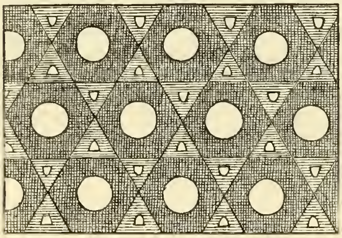
* Since writing the above I have had *M. pilula* sent me (see 'Science-Gossip,' Jan. 1872, and 'M. M. J.,' vol. viii. p. 6), and its habits bear on the views expressed in the text. It is well known that whenever *M. ringens* ejects *fæces* it bends back the disk dorsally over the *anus,* as if stooping over the edge of its tube, the anus then protrudes upwards and shoots the refuse up in a cloud of small particles. To anyone acquainted with the animal the object of this attitude is obvious—it is taken to ensure the free passage away of the fæcal matter, and to prevent it running all round the lobes a second time—the result being that as a fact it goes to the ventral side of the main ciliary wreath, and as it were over the shoulder of the animal and then into the central stream of waste over the chin, and then away. Now *M. pilula* adopts precisely the same course, but with a different result; for whereas *M. ringens* wants to be rid of its *fæces, M. pilula* wants to keep them — the first consolidates the matter within the lowest part of the alimentary canal into an oval brick, and then ejects it into the stream of waste precisely as does *M. ringens;* but instead of its passing over the chin, it is there stopped and caught (the chins of the two animals being very similar), and then laid in the attitude given by Mr. Cubitt ('M. M. J.,' vol. viii. p. 5). If the reader will compare this method of brick-making and brick-laying with that pursued by *M. ringens* (see 'M. M. J.,' vol. xviii. p. 214), I think he will find some interesting conclusions involved in the comparison.

III.—*Note on the Effect produced on P. angulatum and other Test Objects by excluding the Central Dioptric Beam of Light.*

By John Ware Stephenson, F.R.A.S., Treas. R.M.S.

(*Read before the* Royal Microscopical Society, *June* 5, 1878.)

In the hope that it may be of interest to the Fellows of the Society, as illustrating, in some measure, the demonstration by Professor Abbe, that the resolution of lined as well as of some other objects depends on the diffraction spectra produced by the structure of the objects themselves, on the light passing through them. I have this evening placed on the table a slide of *Pleurosigma angulatum* under the new large-angled oil-immersion lens with the centre stopped out, an experiment which also proves, if that be necessary, that in an objective of the best construction the centre is not essential to excellence of definition.



The light passing through the object in the present experiment is transmitted by the achromatic condenser, and is absolutely central. Under ordinary conditions this would show, on taking out the eyepiece and looking down the tube of the instrument, one bright central light from the lamp, with the six equidistant surrounding diffraction spectra, produced by the lines (if indeed lines they be) in the object itself; but at the back of the objective and close to the posterior lens I have placed a stop made of black paper, which *entirely* excludes the central beam of light; in this stop, however, *six* marginal openings have been made, through which the diffraction spectra pass. The result is, that in lieu of the ordinary hexagonal markings, the valve appears of a beautiful blue colour on a black ground, and covered with *circular spots*, which are very clearly defined with the deepest eye-pieces; in fact, it is now so shown with a deep astronomical eye-piece made by the elder Dollond in the early part of this century.

This appearance is in exact accordance with Professor Abbe's theory. In answer to a letter in which I described the effect produced in the above experiment, Dr. Abbe informed me that the Philosophical Faculty of the University of Jena had proposed as a question to the mathematical students the effect produced in the microscope by these interference phenomena, and he enclosed with his reply a copy of a prize essay written thereon by Dr. Alfred Eichhorn. One problem was that of the appearance produced by six equidistant spectra in a circle; these correspond precisely with the *spectra* of *Angulatum*, and the drawing deduced from theory, as shown in the annexed figure from Dr. Eichhorn's essay, is in exact accordance with that now presented by *P. angulatum* under the oil-immersion lens; but the smaller markings between the circular spots of the drawing are indicated by faint points only, under the microscope, without any definite shape, and would possibly have escaped observation altogether had not mathematical theory pointed out that such images ought to appear. The great interest in this drawing is, that Dr. Eichhorn had never seen a diatom under the microscope, and gave graphically notwithstanding the purely mathematical result.

If we still further manipulate the spectra by shutting out each alternate spectrum, leaving only three, we come back again to the hexagonal markings; but, as I have previously shown,* they are three times as numerous as under normal conditions, the length of the sides of the equilateral triangle formed by the spectra being respectively as $\sqrt{3}:1$. Hence we see that we can by regulating the spectra show at pleasure large or small hexagonal markings, circular spots, or even rectangular figures,† the latter form depending on the admission of a spectral image of the second order.

Taking a valve of *P. formosum*, and simply stopping out the centre of the objective as before, one sees on looking down the tube without the eye-piece, the whole of the back of the lens filled with the spectra arising from the right-angled lines (or dots) of the diatom; but in this case, from the coarseness of the markings, the perfect spectra are admitted, and we have a beautiful white object on a black ground; but instead of the " plate of marbles " the appearance presented is that of circular holes punched out of a silvery plate.

Treating a test scale of Podura in a like manner, i. e. with perfectly central light from the condenser and no dioptric beam, we have a silvery scale with parallel black lines running from one end to the other, with a total disappearance of the exclamation markings. This appearance corresponds to a great extent with that demonstrated by Mr. Beck on one of our scientific evenings, on which occasion condensed moisture from the breath could be seen running down the scale.

It will be remarked that the black ground produced by stopping out the centre of the objective differs essentially from that obtained by a stop in the condenser. In one case the light is stopped after entering the objective, and in the other the great obliquity of the incident ray prevents the lens taking it up.

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* 'Monthly Microscopical Journal,' vol. xvii. p. 88.

† 'Journal of Royal Microscopical Society,' vol. i. p. 54.

NOTES AND MEMORANDA.

A New Organ (?) of the Rotatoria.—Dr. Pelletan writes in the 'Journal de Micrographie,' that having for several years undertaken a series of researches on the Rotatoria, and particularly on the Rotifers, he has come to the conclusion, that these beings are very insufficiently known, and that many observations, particularly abroad, seem to have been embellished by their authors so as to resemble somewhat a romance.

"In January last I found in some *Zygnema*, which I had preserved in an aquarium for nearly a year, a great number of rotifers without eyes, furnished with two rotatory lobes of small dimensions, with mastaces of numerous small teeth, and which seemed to me to be the *Callidina elegans* of Ehrenberg. A singular detail struck me. One of them had on the flank of the long segment that may be called the abdomen, a small hyaline vesicle with a double outline, which did not disappear whatever movement the animal made. I considered it at first a parasite, and I pressed a little on the covering glass in the neighbourhood of the rotifer in order to try and detach it. Not far from it two other animals of the same species, which not long previously presented nothing abnormal, had now each a vesicle, but one had it on the right and the other on the left of the abdomen. With a $\frac{4}{10}$ objective I established in the clearest manner that these rotifers carried on each side of the body one and perhaps two stigmata. These stigmata opened and shut as if by a sphincter; they were placed on the summit of a little papilla, situated towards the lower third of the length of the abdomen. When shut they appeared like a point surrounded by a circle, indicating a subjacent vacuole, and bordered by small radiating wrinkles, formed by the integument contracted by the sphincter. When open they presented a festooned border with a clear bottom. I saw them open and shut alternately under my eyes, like the contractile vesicle of a Paramecium, but without regular rhythm; the contraction appeared to me to be voluntary. Seen in profile they constituted a perforation of the integument, and the hernia of the subjacent vesicle by their meatus consequent on the compression, clearly proved to me that the meatus opened to the exterior. As many times as I wished I was able to establish this phenomenon and to cause the hernia. This when produced did not return any more, at least for several hours, and when the animal contracted itself into a ball the hernia persisted.

It is possible that the fact has already been established, but I am not aware of it. I have inferred from it that the mode of respiration amongst the different species of rotifers has been insufficiently known to me, for these stigmata or stomata belong evidently to the respiratory apparatus, and seem to me to have no other end than to admit the aerated water through the thin walls to act upon what may be called the hematose, without the intervention of aquiferous canals, since the vesicle constitutes a close cavity.

It was important to verify the number and exact situation of these stigmata, but unfortunately the incessant movements of the animals rendered the observation difficult, and I have been able to provoke on each of them only the hernia of a single vesicle.

The aquarium having subsequently frozen, the plants and organisms were destroyed. Since then I have never been able to find the rotifer in question. Perhaps I have had to do with the larval state of a species better known at an adult age. I have not the least doubt that my observation was exact—it conformed to what is known of the respiration of certain classes of worms."

A Method of Preserving the Rotatoria, Infusoria, &c., with their Organs Extended.—Referring to the preceding observations, Dr. Pelletan writes :—"The result showed me the necessity of resuming them hereafter, but upon animals rendered immovable at the moment of complete activity, and in all the positions that they are capable of taking. In fact, their extreme mobility and continual changes of form, due to their contractility, are a serious obstacle to their study, and it is only by a long course of fatiguing observations that the same animal can be seen in its different states of extension and under its different aspects so as to obtain a fairly complete idea of it. I therefore endeavoured to find a method which would enable them to be fixed in all attitudes, to preserve them in that state so as to study them in the same way as histological preparations and with high powers, which is ordinarily very difficult with living animals. Under the influence of all the reagents, even with narcotic or anæsthetic agents, the rotifers immediately contract and become only a small globule, in which all the organs, crowded one on the other, show nothing distinctly. It was necessary therefore to find a fixing agent which would enable an absolutely instantaneous effect to be produced.

This reagent is osmic acid. It has always furnished me with excellent results, and I am not aware that it has been previously applied to the preparation of the Rotatoria and Infusoria.

Everybody knows the property which osmic acid has of fixing the histological elements instantaneously in their actual form, but it is not sufficiently known that to act with this instantaneousness it is not enough that it should be concentrated, but it must be employed in a way that its action should not be too much dissipated. Thus if a drop of a solution of 1 per cent. is placed on a tissue, the exact point where the drop has been placed is almost immediately fixed, but the neighbouring parts, over which the acid is diffused and acts only, so to say, at second hand, are subjected to a very much feebler action. If a more concentrated solution is employed there is not much difference in the effect—the action of the acid is exhausted upon the point immediately affected, and does not extend to any distance. It is thus that M. Ranvier has shown that the arms of the hydra may be fixed instantaneously whilst extended, notwithstanding the exceeding rapidity with which they retract them, but the drop of acid must be placed directly upon the little polyp, which can be best done by the ordinary dipping tube.

It is in an analogous manner that I operate on the rotifers and the contractile infusoria. I put about half a cubic centimetre of the solution on the preparation, and at the very moment of the cataclysm all the living beings, animal and vegetable, are instantaneously rendered immovable. I then expose the preparation to a current of air, which takes off the disagreeable vapours of the acid and evaporates the greater part of the water.

I have treated in this manner some filaments of *Vaucheria* collected in March last, and I found that they preserved their form and colour—the protoplasm was not retracted, and they were in fructification. The antheridia and the oogonia were visible with a tint of green much deeper than the rest of the filaments, and containing globules of fatty matter, which the acid had coloured brown or black. The ribbons of the Diatomaceæ, *Himantidium pectinale*, the zigzags of *Diatoma vulgare* preserved their natural aspect and tint, the isolated *Naviculæ* floated in the preparation with some *Cosmarium* and *Closterium* of a green as bright as if they had never been subjected to the action of any reagent, but the motile corpuscles of these Desmidiæ were for ever arrested. Here and there were some Infusoria (*Paramecia*, *Stylonichia*), &c., of a light brown colour—immovable with all their cilia arrested; an *Euglena viridis* of a brilliant green showed its red ocular point and its long flagellum,—all these beings, in a word, seemed still living, and their protoplasm had not changed in form. In the diatoms some globules of a light brown indicated their oily nature, but no other modification appeared to have been produced.

The contractile animalcules were found in all positions. Certain Vorticellæ were immobilized in a complete state of extension, and their peduncle had lost its elasticity. The cuticle ordinarily remained uncoloured, but the internal parts and the muscle of the peduncle were brown. The rotifers were in all attitudes; some completely developed, the wheels exposed and bordered with cilia, which could often be counted. I have counted twenty on the wheel of a *Philodina erythrophthalma*, of which the ocular points, oblique and elongated, like the eyes of a Chinese, remained red. It can easily be established thus that the rings of their bodies, articulated like a telescope, are much less variable than they are ordinarily said to be.

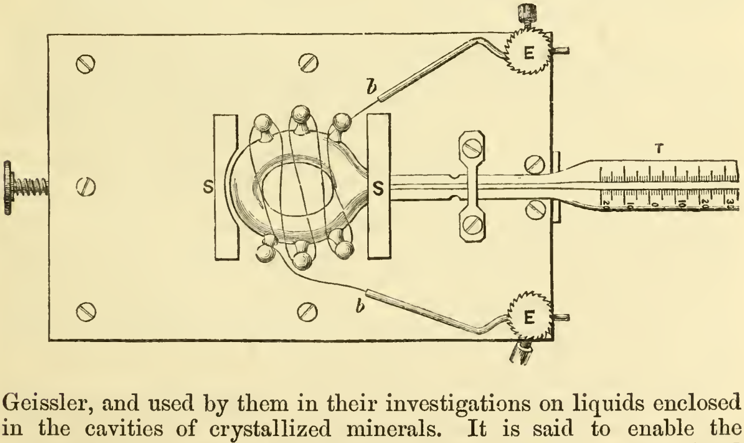
In short, all the living animals were immobilized in the position which they occupied at the moment that the acid touched them.

The preparations thus obtained can be preserved—by passing over them some glycerine the diatoms, desmids, rotifers, and infusoria do not contract, and the preparation can be sealed down. In the Confervæ and the other filamentous algæ, however, the protoplasm is subjected by the glycerine to a very notable shrinking. It is preferable, therefore, to preserve the preparations in a 1 per cent. solution of carbolic acid.

Finally, I should mention that the reagents ordinarily used in histology, and particularly the colouring matters, may be applied to the animalcules. I will give in another paper the very interesting results obtained by these methods, but I should say now that in consequence of the strong action of the osmic acid on the animals (giving them a brownish tint), they colour badly or confusedly by the generality of colouring matters. The method which I have hitherto found preferable is impregnation by a solution of chloride of gold—1 in 400 or 500. The chloride acts in preference on the points where the osmium is already deposited. Its action is, as is known, very inconstant, and the tints which it gives very variable; but the different parts of the same animalcule, coloured a uniform yellowish brown by the osmium, are differentiated in various tints by the action of the chloride. In a *Philodina* I found the integuments colourless, or of a light blue, the muscular bands rose, the intestinal tube brown, the cloaca black (being full), the glandular masses violet, and showing clearly the vacuoles and the rounded cells, with nucleus and nucleolus. The operative process is very simple. It is only necessary to pass the solution of gold under the preparation very slowly, so as not to carry away in the current and lose the animals which are floating. I place a drop of the solution on the edge of the glass and produce on the opposite side a very gentle suction by means of a piece of blotting-paper, which has been passed through the vapour of boiling water, so that without being wet it is not dry, and so that its suction only operates in proportion as it dries. I then place the preparation in the light and wash it (in the same way) with a current of distilled water until the excess of the chloride solution is removed. If the tints are too pronounced the preparation can be treated with a drop of very diluted formic acid, or mounted in glycerine.

I have obtained less satisfactory results when the chloride is put upon the preparation after the osmic acid—the deposit is much more irregular in consequence of the presence of osmic acid in excess, which produces a confused precipitation of the gold."

A New Form of Hot Stage.—In the 'Bulletin de la Société Belge de Microscopie' (vol. iv. 103) an ingenious form of hot stage is described by M. Renard, the invention of MM. Vogelsang and Geissler, and used by them in their investigations on liquids enclosed in the cavities of crystallized minerals. It is said to enable the temperature of a preparation under the microscope to be appreciated with great exactness, and at the same time the phases of the dilatation of



the liquid to be followed corresponding to each degree of temperature. The essential part of the apparatus consists of a thermometer (T), the "bulb" of which, instead of being spherical, is formed into a ring. The thermometer is attached to a brass plate which lies on the stage of the microscope, and the ring is so placed that the interspace coincides with the opening in the stage, and allows the light from the mirror to pass through it. On each side of the ring and soldered to it are three glass "knobs," to which is attached a platinum wire, which crosses above the ring from side to side, serving as a support to the preparation in conjunction with the two pieces S. This wire is attached at *b*, *b*, to two thicker wires of copper, which are kept in place by the screws at E, and when heated by a battery communicates the variations in temperature to the thermometer through the knobs. With a battery of two Bunsen elements the thermometer will register 200° (C.), although such a temperature is not practically necessary, as at 150° Canada balsam boils.

Immersion Paraboloids.—Dr. James Edmunds writes to 'Nature' of 11th July:—"The immersion paraboloid illuminator exhibited at the recent soirée of the Royal Society, as designed by me, proves to have been anticipated in principle and construction by Dr. John Barker, of Dublin, from whom a paper on the subject will be found in the Proceedings of the Royal Irish Academy for 1870. An immersion paraboloid illuminator was also described by Mr. Wenham in the Transactions of the Microscopical Society for 1856. My paper on the subject appeared in the 'Monthly Microscopical Journal' for August 1877, but that Journal being defunct, I ask you to allow me to credit these gentlemen with a priority which on perusing their papers I find to be due to them. I ought to add that until the construction by Messrs. Powell and Lealand of my illuminator, the device had never come into practical use, and that so far as I can learn, no reference to it exists in any optician's catalogue or text-book on the microscope."

Organisms suspended in the Atmosphere.—M. P. Miquel has presented through M. Pasteur a note to the French Academy on this subject. He says:—According to M. Charles Robin the atmosphere presents (besides all kinds of debris) spores, pollen, skins of insects, and (rarely) eggs of infusoria. According to Drs. Maddox and Cunningham, who have confirmed M. Robin's results, the number of the different cellules distributed through the air is independent of the velocity and direction of the wind and of moisture. The collecting apparatus which Drs. Maddox and Cunningham made use of consisted of an aeroscope acting under the influence of the wind, and at each experiment the glycerined plate with which it was furnished remained for twenty-four hours exposed to the action of the wind. Once only the number of the microbia collected reached the maximum figure of 380, after deducting all bacteroid particles.

The results which I have arrived at after eighteen months of daily investigation differ in many points from those which I have just referred to. For the present I shall only deal with the statistical side of the question.

In order to assure to these investigations the precision which, as it seemed to me, they ought to admit of, I suppressed everything which could complicate them; I substituted for the aeroscopes operating by the action of the wind, aeroscopes furnished with a trumpet and a meter which would allow the volume of air which entered in a given time to be measured. This air, projected by an aperture of half a millimetre in diameter upon a drop of a mixture of glycerine and glucose, deposited upon it a part of its solid particles. The experiment was conducted in the park of Montsouris. The trumpet received about 20 litres of air in the hour, and the experiment lasted two days.

Everything remaining constant, the number of organized cellules collected by this process may vary from 500 to 120,000 per cubic metre of air, deducting also in this case all bacteroid particles. If so great a divergence exists between the figures published by Drs. Maddox and Cunningham, and those which I now give, it is obviously to the greater or less perfection of the collecting apparatus that it must be attributed. In fact the aeroscope of Maddox suitably modified gives very good results. Having had an instrument of this kind constructed under my directions, I have collected in twenty-four hours and by a current of 8 kilometres per hour, nearly 30,000 microbia, amongst which were 17,000 grains of pollen. The diameter of the smallest of the cellules which I take into consideration was not less than $\frac{6}{1000}$ of a millimetre.

It is then certain that the atmosphere contains at least a hundred times more germs than Drs. Maddox and Cunningham have stated. I am equally persuaded that with instruments surpassing in perfection those which I now use, the numbers would be very much increased. It is necessary to remember that the corpuscles of every kind which are thus fixed on a glutinous surface are deposited by a jet of air, which only gives up a part and carries away still more with it.

As the result of my researches I deduce the two following general facts applicable to organized corpuscles of the atmosphere whose diameter is greater than the $\frac{2}{1000}$ of a millimetre.

1. The average number of microbia of the air, small in winter, augments rapidly in spring, remains nearly stationary in summer, and diminishes in autumn.

2. Rain always provokes the recrudescence of these microbia.

The increase brought about by rain is not simply sensible, it is often surprising. For example, in summer when to great heat succeeds a storm, or a rain somewhat sustained, the instruments which the day before recorded 5000 to 10,000 germs, record more than 100,000 the next day. The same fact being moreover reproduced in all seasons with a remarkable constancy, I anticipate that new experiments cannot but confirm the general conclusion.

Temperature and moisture seem to me (besides purely local influences) the principal causes of variation in the number of microgerms in our atmosphere.

I will not enumerate here the different organisms which the air carries. I will content myself with indicating generally those which are always found abundantly.

The eggs of the large infusoria are rare. Rain-water introduced with the greatest precautions into flasks (having their necks drawn out and sealed) rarely encloses rotifers, cyclops, keronæ, loxodes, &c., but bacteria are always found, very often monads, and sometimes rhizopods. On the other hand, 40 cubic metres of the dust, immersed in water freed from all germs, habitually give many species of large infusoria, although it may be difficult to recognize at once their eggs amongst the millions of germs in which they are distributed.

The cellules which are most diffused in the air are undoubtedly the spores of the Mucedinæ and of numerous cryptogamic productions, whose diameter varies from $\frac{2}{1000}$ to $\frac{20}{1000}$ of a millimetre. Then come the fructifications of certain fungi whose dimensions, more considerable, sometimes reach $\frac{1}{10}$ of a millimetre. I refer to those septate bodies or germinative masses swollen up in the form of spindles, gourds, or clubs. Then come pollens of very variable size and colour, then grains of starch, which are to the other matters as 1 to 100 or thereabout, and lastly the green algæ which the air transports sometimes in voluminous quantities.

The author concludes by pointing out that it would perhaps be useful and interesting, as bearing on questions of public hygiene, to extend to the corpuscles of the vibrions this kind of statistical study.*

The Foraminifera and Polycystina of the North Polar Expedition of 1875–76.—Mr. H. B. Brady, F.R.S., describes in the 'Annals and Mag. of Nat. Hist.' for June, the results of his examination of the soundings from depths of 10 to 220 fathoms brought home by the expedition. After stating that the area represented by the collection is altogether new, the author says that there are about half-a-dozen species of Foraminifera that may be regarded as essential constituents of the microzoic fauna of these high latitudes, having been found at almost every depth at which the floor of the sea has been examined. They are, *Globigerina bulloides* (a dwarf variety), *Cassidulina lævigata* and *C. crassa*, *Truncatulina lobatula*, *Pulvinulina Karsteni*, and *Polystomella striatopunctata*, usually accompanied by one or two forms of *Nonionina*, varying according to depth and other circumstances, and, if the sea-bottom be composed of rough sand or gravel, by *Polystomella arctica*. Other species occur in every sample of mud or sand, wherever obtained; but it is not too much to say that those above enumerated constitute ninety-five per cent. of the entire collection made from these soundings. The constant occurrence of *Cassidulina lævigata*, of full size and well grown, even when the other Foraminifera accompanying it were poor, starved specimens, and the presence of *Pulvinulina Karsteni* in almost every dredging, to the practical exclusion of all other species of the same genus, are points of considerable significance. The almost complete absence of the Milioline genera (for the occurrence of a single, minute, thin-shelled specimen here and there in a few of the soundings amounts to absence in such a case) is an unexpected feature. In dredgings at similar depths but little to the south of those under consideration

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* 'Comptes Rendus,' vol. lxxxvi. p. 1552.

the simple porcellanous forms are comparatively common; and their area of distribution is otherwise world-wide; yet it is hardly too much to say that no approach to a full-sized mature specimen of any of the modifications of the Milioline type has been met with in the North Polar material. One or two of the species are undescribed hitherto; and a few others present characters somewhat modified by their boreal habitat.

Here and there in the finer portions of some of the soundings, the siliceous tests of Radiolaria were observed; but at one station only, and that the most northerly of all, were they met with in any abundance. Professor Haeckel, to whom the mounts were submitted, considered that the species are, as far as they go, exactly identical with those found in the 'Challenger' soundings from the sea-bottom in the middle of the Pacific, from about 8° N. to 8° S. of the equator, at depths of 2400 to 2900 fathoms. He also confirmed the view which Mr. Brady had already arrived at, that, until we have the wider basis for accurate nomenclature which the publication of the 'Challenger' Radiolaria will afford, it is better to give nothing more than an enumeration of the genera observed.

In summing up the general results the author points out that, with respect to the Foraminifera, we are now able to add to the previous researches (which have rendered account of the Arctic fauna as far north as lat. 76° 30′—that is, to within 13° 30′ of the North Pole)—three further instalments, namely, the group of soundings in Smith Sound and the north of Baffin's Bay, a single one in Hall Basin, and a series to the north of Robeson's Channel. These extend our knowledge of the sea-bottom to lat. 83° 19′ N., a distance of 6° 49′, more than half the interval between the most northerly point of previous researches and the actual North Pole. From a zoological point of view the result is not less gratifying. Sir E. Parry's soundings in Baffin's Bay, which, taken together, furnish the northernmost section of Messrs. Parker and Jones's table, yielded seventeen species of Foraminifera. All but three of these have been found in the soundings; but they form only a small part of the catalogue of fifty-three species which appear in the table accompanying the article. Setting aside the Norwegian lists given by the same authors, as representing a fauna more or less influenced by the warm current of the Gulf Stream, the Hundee Island and Baffin's Bay columns give an aggregate of fifty-five species, or only two in excess of the total now recorded. The facts which have been elicited, therefore, appear to indicate that there is no very striking diminution in the number and variety of the Rhizopoda as we approach the North Pole. Thirteen species are figured on two plates.

On Examining, Preserving, and Photographing Bacteria.—Dr. Koch, of Posen, has published an interesting article in Cohn's 'Beiträgen zur Biologie der Pflanzen,' Bd. ii. Heft 3, of which the following are the chief results:

For a long time attempts have been made to improve the method of examining Bacteria, such as the hæmatoxyline staining of Weigert; the process for the cultivation of Bacteria in long glass tubes introduced by Salomonsen, which rendered their thorough isolation in putrifying blood possible; also the experiments of Frisch on the spread of putrifying organisms in tissues and the inflammatory appearances caused by inoculation of the cornea.

The principal difficulties which arise in investigating Bacteria are, as Dr. Koch considers, connected with their small size, their movement, the simplicity of their form, and their want of colour or power of strongly refracting light. But an equally great hindrance has been the want hitherto of a process for preserving the Bacteria in their natural shape and position, and producing undistorted representations of them. To obviate these difficulties the author adopted a process which consists in drying on the covering glass a very thin film of the fluid containing the Bacteria, in order to fix the latter in a plane. This film is afterwards treated with staining fluids and again moistened, so as to bring back the Bacteria to their natural forms and make them more plainly visible. The preparation is then enclosed in a preserving fluid, and finally photographed, to produce representations true to nature.

The separate parts of this process are conducted as follows:—First, the drying. A drop of the fluid containing the Bacteria is spread out in as thin a film as possible on a covering glass, so that Bacteria, blood-corpuscles, &c., do not overlap, but are separated by a space more or less great. Generally the preparation is ready after a minute or two for further manipulation. Albuminous fluids, and especially blood, are left somewhat longer to dry—if possible, a few hours. Covering glasses thus prepared may lie for months, and the dried Bacteria will be unchanged; they must, of course, be carefully protected from dust. The objection which might be raised against drying them thus, viz. that their form must thereby be considerably altered is, as experience has taught the author, unfounded; for he observed, to his astonishment, that the Bacteria did not shrink together into shapeless masses; but, like rigid bodies surrounded by a slimy sheath, adhered to the glass by this sheath, and dried without visibly altering their shape, particularly as to length and breadth.

The second part of the process consists in moistening and staining the dried film. For the moistening a solution of acetate of potash (one part in two parts of distilled water) may be used with good results; a swelling without separation from the glass being brought about, and at the same time the Bacteria resume perfectly their original form, only appearing rather paler and more transparent than before. Since the Bacteria which have swelled up again in this fluid do not change any further, it is specially adapted to preserve the preparation, which may be forthwith cemented.

The Bacteria are often too pale for examining and photographing, and must be made more distinct by being stained. For this purpose the aniline colouring matters appear to the author to be the most suitable. The Bacteria take, in fact, the aniline stain so quickly and completely that these colours may be used as reagents, to distinguish Bacteria from crystalline and amorphous precipitates, as also from the finest fat-globules and other minute bodies. Moreover, the aniline dyes, in their solution in water, act like the acetate of potash, as they soften the film but do not loosen it from the glass. Amongst the aniline colours, methyl-violet and fuchsin appear to the author to work best; he especially recommends the methyl-violet which is marked B B B B B in the price lists. When it is wanted to make the object more conspicuous for photographic plates aniline brown should be used.

For preserving the preparations thus stained, either Canada balsam, a concentrated solution of potash, or glycerine may be used. Those preparations only which have been coloured in methyl-violet or fuchsin are adapted for placing in balsam. After being taken out of the staining liquid they are thoroughly dried and laid in the balsam in the usual way. Preparations coloured with methyl-violet and fuchsin, when they are to be photographed, must, in order to preserve the Bacteria in the most natural form, be placed, whilst still moist, in the solution of acetate of potash, and that must be done directly after they are taken out of the staining solution, and they should then be sealed. Glycerine, as it takes out the colours, will not do to place these preparations in; on the other hand, it is the best preserving fluid for preparations coloured with aniline brown.

As regards photographing, the Bacteria are not different from other microscopic objects. As, according to the process above described, the film to be photographed is immediately under the covering glass, the employment of the strongest immersion objectives is possible. Under favourable conditions living Bacteria, which are not in a state of motion, may even be photographed, of which the author gives an example in a "photogram." He draws attention to the fact, that the photographic plate reproduces the microscopic image generally better, that is more surely, than the impression on the retina of the eye can be. The article itself gives very explicit details of the process in photographing.

As proof of the excellency of the productions obtained by his process the author gives three plates, containing twenty-four specially fine "photograms"; on which the most delicate details, as, for instance, the flagella of the Bacteria, are plainly visible.*

A Moist Chamber of very simple construction for observing the copulation of the *Spirogyra* is described by Dr. Strassburger, in his book on 'Fertilization and Cell Division.' It consists of a ring of cardboard soaked in water, on which the covering glass is placed. The drop of water containing the *Spirogyra* must be suspended from the under surface of the covering glass, and may then be preserved for several days, and the copulation readily observed. If the plants are placed under the covering glass in the usual way, they will infallibly die.

The "Zentmayer" New Patent Microscope.—This instrument, which has just been introduced into this country by Messrs. Ross, resembles in appearance the well-known Jackson form of stand, but differs from it in the following particulars:—

The limb supporting the body with the slide for quick adjustment,

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* 'Zeitschrift f. Mikroskopie,' vol. i. p. 119.

carries also a second slide, parallel with, and at the back of the other, by means of which a slow adjustment is obtained by the action of a stout steel lever passing through a channel in the limb; the lever is acted upon by the ordinary micrometer screw in conjunction with a stiff steel spring. This arrangement permits of the milled head of the fine adjustment being placed in a most accessible position, on a step above the trunnions supporting the limb and body of the microscope, almost similar to the fine adjustment in the old Ross model. This simple fine adjustment, when in use, leaves the body of the instrument quite untouched, and therefore not liable to swerve; an evil of common occurrence in cases where the fine adjustment is attached to the body itself. The magnification of objects is not altered by a difference in the length of body, as is more or less the case when the fine adjustment is obtained by means of a cylinder sliding in the nozzle of the instrument, and the thickness of an uncovered object on the stage can be directly measured by means of a divided scale and vernier which can be attached to the limb at the edge of the fine focussing slide.

The most important feature of the Zentmayer stand consists in an improved method by which the tail-piece or stem carrying the mirror, sub-stage, with all illuminating apparatus, can be turned aside or swung on a tubular pivot (placed at the back of the stage), the centre of which is in a line in the optic axis intersecting the plane of the object on the stage, and consequently also in the focus of the object-glass.

The use of this swinging tail-piece arrangement enables condensing and other lenses for concentrating light to be used at any angle below or even above the stage if required, affording peculiar facilities for obtaining oblique illumination, and in the adaptation of appliances to be used for the purpose. For registering the angle at which an object is best observed there is a divided arc on the upper segment of the swinging stem.

With the usual form of microscope stand, in which a fixed stem supports the sub-stage, oblique light has to be obtained either by the use of separate reflecting prisms or admitting light through peripheral stops from the margin only of high-angled condensers. These necessarily come very close to the slide, and there is a difficulty in regulating the obliquity of deficient marginal rays. In the Zentmayer stand, however, with the use of the swinging arrangement, condensers and illuminators of long focus can be used with great advantage, and abundance of light is obtained with low-power object-glasses such as the 1 inch and 1½ inch.

In order to get the best results for oblique illumination a very thin stage was found to be requisite; a simple mechanical stage, with concentric rotary movement, has therefore been designed specially for this instrument by Mr. Wenham, having only one movable plate in its construction, the rectangular directions of which are performed by two concentric milled heads, something similar to the well-known Turrel stage. This stage is supported by a conical stem, which passes through the tubular pivot of the swinging tail-piece arrangement, and is clamped at the back of the instrument by a strong screw and nut. This stage can be readily removed from the instrument and replaced by any other form of object support to suit the special requirements of microscopists.

The idea of swinging the sub-stage and illuminators on the line of the object under observation is not a new one, several plans having been adopted from time to time by different microscopists to effect this. The most important was the subject of a patent more than twenty years ago, by Mr. Grubb, of Dublin, who fixed, *exterior* to the stage, a sector comprising nearly a semicircle, upon which the attachments for the illuminators were made to slide. The centre of the arc was set so as to be coincident with the object in focus on the stage. The Zentmayer system, however, of swinging the sub-stage is the most simple yet devised, and does not interfere with the stability or ordinary use of the instrument, for when the swinging bar is clamped in line the peculiarity at first sight is not readily observed, and the contrivance of this effective arrangement is very creditable to the ingenuity of Mr. Zentmayer.

Digestive Apparatus of Spiders.—M. F. Plateau has communicated papers on this subject to the Académie Royale of Belgium, in whose 'Transactions' they will be found, and in the 'Bulletin of the Société Belge de Microscopie,' January 31, 1878. He states that the dipneumonous spiders have the pharynx and œsophagus so narrow, that the juices of their prey penetrate the buccal intestine by capillarity; the dilatation of the suction organ driving them forward. When this organ contracts, the narrowness of the tube obstructs their return like a cork, and they are propelled into the middle intestine. In the first part of their course they are mixed with the pharyngeal secretion, which may have the properties of insect saliva, but no experiments have been made with it. From a mechanical point of view, the cæca of the middle cephalo-thoracic intestine only play a passive part; and if they serve as reservoirs, the liquids only enter them by the pressure occasioned by the suction organ. The cæcal secretion is not acid, and probably not analogous to gastric juice. It is an error to suppose the middle cephalo-thoracic intestine of spiders is analogous to the stomach of vertebrates. The principal digestion of albuminous, starchy, and fatty matter is effected by the energetic action of the liquid specially secreted by the abdominal gland, which is generally yellow, and containing fine granules, fat-globules, and epithelial cells, more or less intact. It is slightly acid. As with insects and decapod crustaceans, the acting ferment is evidently different from the pepsine of vertebrates, and an addition of a feeble trace of hydrochloric acid, instead of enlivening its action, completely stops it; but, like the pancreatic juice of vertebrates, certain salts, such as carbonate of soda, slightly promote it. This liquid rapidly transforms starch into glucose. The abdominal gland of the spider is not a liver, although its containing glycogen, together with its form, tend to the supposition. Its liquid does not exhibit the properties of bile, nor its colour with reagents. It rather resembles the pancreas of vertebrates, but the likeness is not perfect. The matters accumulating in the middle intestine pass onwards through the action of the very thin muscular coat of this portion of the digestive tube, and probably also under that of the muscular columns. This mass divides and becomes surrounded with a thin envelope secreted by the epithelium of the intestine. The result is the production of solid excrements, which collect in the stercoral pouch. A chalky liquid secreted by the malpighian vessels also collects there, and exhibits innumerable corpuscles, extremely small, discoid, or spherical, grouped in pairs, and sometimes accompanied with microscopic crystals in rhomboidal tables. The secretion of these tubes is neutral and contains salts, amongst which is chloride of sodium. So far as can be judged, it does not contain uric acid, or urates, but it is easy to show the presence of guanine. The stercoral pouch is a reservoir collecting the residues of digestion, and the malpighian products. Its contents are expelled at considerably long intervals under the influence of its well-developed muscular coat. We must remember, finally, that the dipneumonous spiders can live for many months, that is to say, during the whole season of physiological activity, without food.

Hooked Spines on the "Root-fibres" of British Polyzoa.—In No. 72 (Zoology) of the 'Journal of the Linnean Society' Mr. C. W. Peach, A.L.S., writes in regard to *Scrupocellaria scruposa*, that although it is common and well known he is able to add a little to its history. Having received a specimen on a sponge (*Halichondria panicea*) from the Frith of Forth, and desiring to know how it moored itself to the soft body, he cut open the sponge, and found, as he thought, curious sponge-spicules, differing from all he had previously seen. On tearing it from the sponge, he saw that the "spicules" were actually the "tubulous root-fibres" of the *Scrupocellaria*. Having hitherto considered these "root-fibres" as smooth, with a disk for adhesion to anything, at the lowest end, it was a new fact to find that they were armed with stout hooked spines where they were buried in the sponge, the points of the hooks bent towards the zoophyte, like the flukes of an anchor pointing towards the bow of a ship when the cable is stretched tight. These hooked spines are shaped like the thorn of a rose tree, and surround the "root-fibres" in a rather irregular manner, and when dragged out of the sponge hold in their grasp numbers of the sponge-spicules; this at once explained why these "root-fibres" were armed with hooks, and the points bent towards the zoophyte.

In another specimen from the same locality it was found that the spines, &c., were constant under similar circumstances. A specimen of *Canda reptans*, collected in Cornwall before 1849, on examination, showed similar hooked spines on the "root-fibres." In the hope of confirming this with a Scotch specimen, *Canda reptans* was got from Newhaven (N.B.), unfortunately not on a sponge, but on *Flustra foliacea*; here the hooks were absent; but the tips of the "root-fibres" were furnished with short radiating processes spread out at right angles, and from these short disk-like processes were inserted into the openings and body of the cells of the *Flustra*, thus giving a firm grip on this larger fan-shaped and firmer support, and enabling the zoophyte to ride safely in a storm.

Here, then, we have curious instances of things low (?) in the scale so well adapting themselves to changed circumstances as to secure their safety and preservation. In no works on British Zoophytes is there any notice of these hooks.

A New Postal Box for Slides.—A new form of box for sending slides by post has been suggested in America by Dr. R. H. Ward, and is said to have "proved successful beyond anything tried before," in saving the slides from injury. The arrangement consists generally in removing the racks, and lining the top, bottom, and end of the boxes with thick, soft cloth, and arranging folds of the cloth, glued or stitched in place, like a rack at each end of the box, so that a double thickness of the cloth shall extend between the slides from each end one inch towards the centre. It is described in detail in the 'American Naturalist' for February, and Hardwicke's 'Science-Gossip' for April.

A "New" Box for Microscopic Slides.—In the 'American Journal of Microscopy' for May, Dr. Carl Seiler suggests that the racks of the boxes for slides should slant at an angle of 130° to the bottom of the box, the inclined position of the slides then obviating, as is said, the difficulty there is in reading the labels when the slides are upright (as well as the difficulty in getting them out), or injury by their sliding over one another when flat. This plan was exhibited in England many years ago, but discarded on account of its inconveniences.

Apparatus for resolving Test Objects.—Mr. George Williams, of the Quekett Microscopical Club, has contrived an apparatus for facilitating the use of the small bull's-eye illuminator devised by Messrs. Powell and Lealand for the resolution of *Amphipleura pellucida.* That illuminator Mr. Williams points out operates successfully on those specimens only which happen to lie in the direction of the width of the slip or within very narrow limits of it, the rest of the specimens being, from their position, wholly unsuitable for examination. If the slide is turned by rotating the stage of the microscope, the length of the slide quickly interferes with and pushes aside the bull's-eye. To overcome this difficulty is the object of the apparatus, which consists of a tubular disk-holder 1 inch long and $\frac{3}{4}$ inch diameter, the top cut out so as to leave three equidistant $\frac{1}{4}$-inch uprights (as slender as possible, so as not to obstruct the light), with small lips, upon which can rest parallel a disk of thin plate or crown glass on which the diatoms are mounted. The tips of the uprights are slightly inclined inwards, to spring lightly against and steady the disk to overcome the suction of immersion objectives. The disk-holder slides over a tube fixed to a brass plate with a central hole, which is attached by screws to the stage of the microscope. The bull's-eye condenser is attached to the stand, and either the disk-holder or the stage of the microscope can then be rotated to get any particular specimen into position.* A further improvement has been suggested, by substi-

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* 'English Mechanic,' vol. xxvii. p. 307.

tuting for the brass plate a Darker's revolving selenite stage, by means of which the disk-holder can be readily rotated.*

Terricolous Rhizopoda.—M. A. Schneider has presented through M. de Lacaze-Duthiers to the Academy of Sciences the following note:—

It is known that some rhizopods are able to live on land. De Greeff has described six or seven species—*Amœba terricola* and *Arcella arenaria* amongst others. We have found these latter forms and ten others incontestably new, and all belonging to the group of Amœbæ furnished with a test. The test has more or less the form of an ovoid, sometimes drawn into a neck at one of its extremities, and nearly always compressed so as to present two distinct faces. It appears to be chitinous, sometimes thin and transparent, and figured with hexagons, areoles, circles, &c., sometimes thicker and coloured brown, and in a very common *Arcella* formed as if by an agglomeration of small grit. It has only one orifice smooth or indented, terminal or situated on one of the faces bevelled out to receive it.

The sarcode body of the interior, observed in a state of repose, is clear and homogeneous without granules in its lower third part, which encloses only the nucleus and two or three contractile vacuoles. At the limit of this lower third and the two upper thirds is seen a layer of fine yellowish granules spread out in a transversal plane. The two upper thirds are formed of a protoplasm more or less irregularly granulous, with or without foreign bodies in process of digestion.

The nucleus, always spherical, encloses one or many nucleoles.

When the animal is active this distribution of its constituent elements is disturbed, and it is seen to emit by the orifice of its shell pseudopodia which resemble in their general features those of the amœba, and whose length may reach to double that of the shell. To emit these pseudopodia the animal detaches itself more or less from the internal walls of its habitation, to which it only adheres at various points by protoplasmic filaments.

If the exterior conditions become unfavourable the rhizopods retract and encyst themselves. In the interior of the shell is then seen a regular sphere, in which all the elements of the structure of the animal are recognized, enclosed with foreign bodies.

A certain number of these expelled before the encystment may form a protecting barrier at the orifice of the shell. On adding a little water they are seen to break the frail envelope of their cyst and to resume possession of their quarters.

We have seen conjugation in the case of four of the species, and there is reason to believe that it occurs in all.

To this conjugation succeed cysts whose contents represent sometimes those of the two contractants; sometimes those of one only; each one then encysting for itself after an ephemeral union with the other.

These cysts of reproduction give spherules or spores, the evolution of which we have not yet followed, but which we hope to be able to

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* 'English Mechanic,' vol. xxvii. p. 370.

observe before the complete publication of the preceding facts in the 'Archives' of Professor de Lacaze-Duthiers.*

The Life-History of a Minute Septic Organism: with an Account of Experiments made to determine its Thermal Death Point.—A paper under this title, by the Rev. W. H. Dallinger, was read before the Royal Society in May last. It was an account of a hitherto unrecorded organism, belonging to the septic series, which was found in the earlier stages of the decomposition of the macerating body of a vole. It was studied by the aid of the "continuous stage" used by Mr. Dallinger and Dr. Drysdale in their "Researches on the Life-History of the Monads," by means of which a drop of the septic fluid containing the organism can be kept under examination for an indefinite time, without evaporation; and be studied with the most delicate and powerful lenses. The method pursued was continuous study, first of the details of the several metamorphoses, and by the light thus gained, a continuous study, subsequently, of their sequences in the same individual form.

The majority of the most difficult and delicate work was done with a new $\frac{1}{35}$-inch lens, made for the author, with a special view to this class of observation, by Messrs. Powell and Lealand.

The organism never exceeds the $\frac{1}{4000}$ of an inch in long diameter; it is oval, with a constriction slightly in front of its short diameter; and at its anterior extremity has a head-like protrusion, to which is attached a long delicate flagellum. At the sides of the shorter, or front segment of the oval, somewhat in the position of "shoulders," two long fine flagella proceed, and as a rule trail with exquisite grace behind; one on either side. It swims with great rapidity and has every variety of motion in the fluid; and in the accomplishment of its evolutions its lateral flagella are largely concerned. But besides its swimming power, it has the capacity to anchor both its trailing flagella to the floor, or the stage, or to a decomposing mass, and by coiling these flagella, and bringing itself down upon the body to which it is anchored, and then suddenly darting up so as to make its flagella, together, the radius of a circle, it darts down on the decomposing substance, and by the enormous numbers that are constantly doing it, aids in the rapid breaking up of the tissues.

By steadily following it in the free-swimming condition it was seen to undergo fission or self-division, which was a very complex and extremely delicate process; the division beginning in the front flagellum and proceeding until, by longitudinal division, a new lateral flagellum was, in the act of self-division, made for each half; and by the snapping of this both halves went free as perfect organisms, soon to commence the process again. A great deal of close and careful detail was given of this process, and was accompanied by illustrations drawn from nature. There were also accounts of a series of observations on the frequency of the recurrence of the process of fission, by the continual following of one segmental product of the act; and also, from its beginning to its cessation, in a series of separate

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* 'Comptes Rendus,' vol. lxxxvi. p. 1557.

organisms, making manifest the periods of greatest fissional intensity; and also showing the result following on the cessation of fission. In the majority of cases it was an exhaustion of vital action and death; but in a certain proportion, in which fission was not so long continued, it was a rapid change to an amœboid condition, resulting in the absorption or fusing of the lateral flagella with the body, and a change of form; the organism becoming now quite oval and having only an anterior flagellum. It swims easily, but has lost all the power and freedom of motion possessed before, moving only in a straight line. But it soon comes into contact with a colony of the organism in the springing condition, attaches itself to one of them, which then soon unanchors, and both swim away. In the course of time their movements become sluggish; the sarcode of the bodies is palpably blending, they become quite still, except for amœboid movements, and then become one mass, oval in form, which elongates into a spindle-shape, remaining motionless and still in all respects for three or four hours; when, as was ultimately and by long-continued effort made out, it pours out exquisitely minute, opaque, apparently round specks, which, when carefully and steadily followed with the best appliances, were seen to develop into the adult form and size.

The author then desired to discover the relative heat-resisting power of the perfect form, and the germ or spore. The adult forms were proved by a very direct method, which was fully detailed, to be wholly destroyed at a temperature of 142° Fahr. Two methods of heating were employed to test the resistance of the spore. One was the "dry" method which had been employed in the former researches; but which was somewhat modified and used with special precautions; and the result of an elaborate series of experiments proved, that by this mode of heating, the spore could resist a temperature of 250° Fahr.

It was next determined to test the heat resistance of the spores when they suffered the heat, diffused in a fluid. The difficulty of accomplishing this, so as to secure an unmistakable result, was carefully pointed out and dwelt on; and the opinion recently expressed by Dr. Bastian that it was "perfectly easy" shown to be an error.

The apparatus employed for the purpose was specially delicate, but enabled the author to test directly the results of heat on the spores as well as on the adult organism, without exposure after the vessel was once sealed. The form used was specially devised for these observations. The temperatures up to the boiling point of water were got in melted paraffin, and higher temperatures in a digester. The result was that 220° Fahr. was found to be the limit of temperature which the spore of this organism could endure without destruction of vitality. That is to say, 30° Fahr. lower than the same spores could bear in a "dry" heat. But it was pointed out, that to endure this temperature, implied protection of some kind; but that this in the *undeveloping* germ was not only capable of being understood, but would doubtless prove of immense value to the organism.*

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* 'Nature,' No. 447, p. 102.

The Fine Adjustment of English Microscopes.—Many of the foreign writers on the microscope condemn the form of this adjustment, because they say that on account of the amplification constantly varying in consequence of the variation in the length of the tube, precise micrometric measurements are impossible. Dr. Van Heurck, the Belgian botanist and microscopist, writing in the 'Bulletin' on the new oil-immersion object-glass and the advantages it offers in dispensing with any correction adjustment, says, that it is curious that those who have thus criticised the fine adjustment should never have criticised the correction collar, for to that their objections particularly belong. By very precise experiments made with a cobweb micrometer, he satisfied himself that even with a $\frac{1}{25}$ the difference of amplification was insignificant, when with a Ross microscope the tube was lengthened or shortened to the full extent of the fine adjustment. With, however, an $\frac{1}{8}$ or $\frac{1}{10}$, variations in the amplification of 100 diameters were obtained from the different positions of the correction from 0 dry to the extreme limit for immersion.

The Ornamental Colours of Daphniadæ.—A long and interesting paper on this subject by Dr. A. Weismann appears in Siebold and Kölliker's 'Zeitschrift,' vol. xxx. suppl. 123, illustrated with a plate in colours. Dr. Weismann, it will be remembered, originated some elaborate investigations into the "terrifying" colours of animals. The author thus summarizes the results of his researches:—

1. Only a small number of Daphniadæ have variegated colours, which are for the most part developed in both sexes, seldom only in one, and partly in equal and partly in different degrees.

2. This colouring must be regarded as a decoration which was first acquired by one sex alone (probably for the most part by the males), but afterwards transferred in most cases to the other sex also. It is conceivable that this transfer was materially accelerated by the introduction of an alternating sexual selection, so that at the commencement of every sexual period, the males, at that time few in number, chose the most beautiful females, but towards the end of the sexual period the females made the selection from among the relatively more numerous males.

3. The acquisition took place probably at a time when already a part of the year's breed multiplied only parthenogenetically. From the constant difference in colours between neighbouring colonies it may be concluded with some probability that the development of the colours only began after the isolation of the colonies, i. e. after the Glacial period in Northern Europe.

4. The transfer took place in a threefold direction, according to the law of homochronic transmission of Haeckel, modified by the gradual "retrogression of character,"—first to the other sex; secondly, towards the stage of growth when the sex is undeveloped, or at least full growth is not yet attained; and thirdly, to the parthenogenetically produced generations. In all three cases the different species which are provided with ornamental colouring are found in different stages, the highest stage, i. e. the perfect transfer of the colouring to both

sexes, all stages of growth, and all generations of the yearly cycle, is only obtained by one species (Latona).

5. The Daphniadæ furnish thus a further proof that secondary sexual characteristics may become general characteristics of species, and illustrate the Darwinian views of the origin of the colours of butterflies.

Schulze's Mode of Intercepting the Germinal Matter of the Air.—Professor Tyndall contributes a paper on this subject to the Royal Society, of which the following is an extract:—

In 1836, Schulze described an experiment which has obtained considerable celebrity. He placed in a flask a mixture of vegetable and animal matters and water. Through the cork two glass tubes passed air-tight, each being bent at a right angle above it. He boiled the infusion, and while steam issued from the two glass tubes he attached to each a group of Liebig's bulbs, one filled with solution of caustic potash and the other with concentrated sulphuric acid. Applying his mouth on the potash side he sucked air daily through the sulphuric acid into the flask. But though the process was continued from May till August no life appeared.

In this experiment, the germs diffused in the atmosphere are supposed to have been destroyed by the sulphuric acid, and doubtless this was the case. Other experimenters, however, in repeating the experiment of Schulze have failed to obtain his results. Schulze's success is perhaps in part to be ascribed to the purity of the air in which he worked; possibly also to extreme care in drawing the air into his flask; or it may be that the peculiar disposition of his experiment favoured him. Within the flask both glass tubes terminated immediately under the cork, so that the air entering by the one tube was immediately sucked into the other, thus failing to mix completely with the general air of the flask.

At a very moderate rate of transfer, I found, in 1869, that germs could pass unscathed through caustic potash and sulphuric acid in succession. To render the experiment secure, the air-bubbles must pass so slowly through the acid that the floating matter up to the very core of every bubble must come into contact with the surrounding liquid. It must of course touch the acid before it can be destroyed.

Reflecting on this experiment, and knowing that a sealed chamber simply wetted within suffices to detain the floating matter coming into contact with its interior surface, I thought that the same must hold good for the air-bubbles passing through a group of Liebig's bulbs. Every bubble, in fact, represents a closed chamber of infinitesimal size, and it seemed plain that if the walls of this chamber were formed of water instead of sulphuric acid, the floating matter would be effectually intercepted. This conclusion I verified by experiment.

Two large test tubes, each about two-thirds filled with turnip infusion, completely sterilized, were so connected together that air could be drawn through them in succession. Two narrow tubes passed through the cork of each test tube in the same manner as in Schulze's flask, and it was so arranged that the tube which delivered the air should end near the surface of the liquid, the exit tube in each case ending immediately under the cork. Two series of Liebig's bulbs, charged with pure water, were attached to the two of this arrangement, one being connected with a large receiver of an air-pump and the other left open to the air. The connection between the receiver and the adjacent bulb being first cut off by a pinch-cock, the receiver was exhausted, and by carefully loosening the pinch-cock a very slow passage of the air through the test tubes was secured. The rate of transfer was, however, such, that the air above the infusions was renewed twenty or thirty times in twenty-four hours. At the end of twelve days the turnip juice was perfectly pellucid and free from life. Two days' exposure to ordinary air sufficed to render it muddy.

After twelve days the pinch-cock was opened so as to allow a momentary inrush of the external air, which was immediately checked by the reclosing of the cock. Three days afterwards the infusion of the test tube into which the air first entered was muddy and crowded with life. The contamination did not reach the second test tube. Similar experiments completely verify the conclusion, that in Schulze's experiment water may be substituted for sulphuric acid and caustic potash without any alteration in the result.*

The Ordinary Microscope as a Polariscope for Convergent Light.—Professor A. de Lasaulx, of Breslau, describes in the 'Bulletin of the Belgian Microscopical Society' a method of using the microscope for this purpose. He points out that the ordinary polarizing instruments, whose magnifying power is always feeble, scarcely allow the examination by convergent light of small particles or the ordinary microscopic lamellæ of minerals requisite for the petrographic study of rocks, so that in the examination of very small crystals it becomes difficult to determine the parts most suitable for examination, or to grasp a number of optical details. For these observations, however, the ordinary microscope with two Nicol prisms is available—all that is necessary is to remove the eye-piece, and to work with the objective alone between two crossed Nicols. There is then so strongly convergent a light that the interference figures can be seen even in the thinnest plates. According to the dimensions of the plates under observation a high-power objective can be employed, but with the higher ones (as Nos. 7 and 9 of Hartnack) the field is not entirely round. This can, however, be corrected by applying to the lower Nicol two lenses, one of 12 mm. focus, and the other 6 mm., and so arranged that each of the two can be used separately or together, in the latter case giving a focus of about 5 mm. A completely round field is thus obtained even with the highest objectives.

By this method it is easy to see the phenomena of interference presented with convergent polarized light by crystals, which only become diaphanous when they are reduced to an excessive thinness. For instance, the figures of substances which exhibit rotatory polarization can be seen in thin plates cut perpendicularly to the vertical axis, as in cinnabar—also the black cross in the small scales of mica enclosed in the thin plates of certain basalts. The employment of

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* 'Proc. Roy. Soc.,' No. 185.

the microscope as a polariscope is also specially advantageous for the study of small macled crystals of a structure more or less complicated and rich in interlacings, which only become visible with polarized light. With the eye-piece in place, these crystals can be examined with parallel light, and their peculiarities of structure and other points taken note of. The plates most suitable for examination can then be placed exactly in the centre of two crossed threads in the eye-piece, and on removing the latter, they can be examined with convergent polarized light. By this simple method the extremely complicated crystals of Phillipsite have been observed, also of Silesian Sirgwitz, which are only diaphanous when reduced to the thinnest plates. The small crystals of Tridymite were by these means shown by the author not to be hexagonal, as was considered from its pseudo-hexagonal form, with one optic axis, but biaxial—the two hyperbolas being plainly seen.*

Quekett Microscopical Club.—Professor Huxley, F.R.S., has been elected to the office of President of this club for the ensuing session.

Stromatopora as distinguished from Millepora.—Dr. Dawson, F.R.S., of Montreal, writes to the 'Annals of Nat. Hist.' (July) that the April number, containing Mr. Carter's paper, "Identity in Structure of *Millepora alcicornis* and *Stromatopora*," reached him not long after the completion of a series of careful microscopic studies of the *Stromatoporæ* and allied forms which abound in all the American limestone formations, and had arrived at the conclusion that these fossils appertain to the group of Rhizopods. After reading the paper, he re-examined the specimens of Millepora, but with the result of failing to find any indications whatever of the affinities asserted by Mr. Carter; and he gives the grounds for disputing what he terms "the somewhat extraordinary identification of two classes of organisms which scarcely resemble each other in anything except in being calcareous and porous."

Dr. Dawson mentions that having in his possession at present a considerable number of duplicate specimens of *Stromatopora*, in such a state of preservation as to show under the microscope their actual structure, he will be happy to send by post chippings of these specimens to any naturalists desirous of studying them and of comparing them with such organisms as *Loftusia* on the one hand or *Eozoon* on the other, with both of which the *Stromatoporæ* have decided affinities.

Professor Schwann's Jubilee.—The fortieth anniversary of the professoriate of the co-author with Schleiden of the "Cell theory," and author of 'Microscopical Investigations on the Identity in the Structure and Growth of Animals and Plants," was celebrated at Liége on June 23. The celebration included a laudatory oration of the Professor, the presentation of addresses from learned bodies throughout Europe, and of an album of living biologists, the unveiling of a bust, and, lastly, a banquet. Mr. F. M. Balfour, of Cambridge, represented England.

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* 'Bulletin de la Société Belge de Microscopie,' vol. iv. p. 177.

Glyciphagus plumiger. — In 'Science-Gossip' for July, Mr. A. Michael mentions the capture by him of this acarus in England, in fodder in a stable. Though only one other case of its capture here is on record, Mr. Michael considers that from the fact of it having been found in two remote parts of the country, between which there would not be likely to be communication, and which are both agricultural, it may be fairly claimed as a British species, although only a single individual has been detected in each instance. A woodcut of the female (not previously figured) is given.

A New Family of Calcareous Sponges.—Mr. H. J. Carter describes, in the 'Annals' for July, two new species of calcareous sponges, in which the excretory canal-systems do not open into a common cavity (the "cloaca" of Dr. Bowerbank) which discharges itself at one or more apertures, but open directly upon the surface.

Mr. Carter gives the following description of the single genus of the family :—

Teichonellidæ (τεῖχος, a wall), new family. *Character.*—Vallate.

TEICHONELLA, nov. gen.

Generic characters. — Vallate or foliate, without cloaca. Vents numerous, confined to the margin, or general on one side of the lamina only; naked.

Both the species *T. prolifera* and *T. labyrinthica* (which are described at length and illustrated in a plate of nine figures) are in the British Museum—the former (which is by far the largest Calcisponge on record) for many years and the latter (only second to it) were in Dr. Bowerbank's collection purchased by the Museum. Referring to Professor Haeckel, Mr. Carter considers it "somewhat laughable that the self-constituted author of 'The History of Creation' should have omitted a whole family of the Calcispongiæ."

The Polarizing Microscope in Mineralogy.—At the session of 4th February last of the French Academy of Sciences, a note by M. A. Michel Levy was presented by M. Des Cloizeaux, on the use of the polarizing microscope with parallel light for the determination of the species of minerals found in thin plates of eruptive rocks, by means of the depolarizing axes which the crystallized elements of these minerals evince in parallel light between two crossed Nicols.

The crystallographic orientation of these elements is generally indeterminate, and the employment of the polarizing microscope with parallel light is alone possible on account of the minuteness of the crystals and the extreme tenuity which must be given to the plate to render it sufficiently transparent. But these inconveniences are compensated by the large number of crystals which can be operated upon, and by the elongation which certain species assume in a particular direction.

M. Levy proposed to study the variations in the position of the depolarizing axes of a given mineral with respect to the different sections which were produced parallel to its edge of elongation, by finding the angle of each position of the depolarizing axis with that edge, the direction of the same being constant. In fact, the sections belonging to this zone may generally be distinguished at the first glance in a thin plate, and they strike the eye by their characteristic elongation and the known relation of this elongation to the facile sections.

M. Levy has determined under these conditions the angles of the depolarizing axes of pyroxene, diallage, amphibole, epidote, sphene, and orthoclase, and has determined in triclinic feldspars that some specimens belong to oligoclase and some to labradorite.

The Radiolaria.—To all who are interested in this group may be commended the perusal of Mr. St. George Mivart's paper, which is printed in No. 74 of the 'Linnean Society's Journal' (Zoology). The paper, though headed "Notes touching Recent Researches on the Radiolaria," is in reality a condensed treatise on the group; and, whilst constituting somewhat of an innovation upon the usual practice of learned Societies, will be generally thought to establish a valuable precedent, and one that might be very usefully followed with other subjects and in other Societies, particularly where, as is the case with the Radiolaria, the results of their investigation are for the most part locked up in a foreign language. Mr. Mivart thus prefaces the paper:—"The example which has been set by our President in publishing from time to time in his successive addresses a digest and *résumé* of the most recent researches which have been carried on respecting certain of the lowest animal groups, has led me to believe that a similar course might advantageously be taken with respect to the Radiolaria. Our publications already afford, through Dr. Allman's recent labours, the readiest means of obtaining a knowledge of the most modern investigations with respect to various groups of Protozoa, and I have myself found the memoirs referred to most valuable and useful. I hope that other Fellows may adopt a similar course, so that our journal may become a complete repertory of information respecting all the lower groups of the animal kingdom. No English publication on the Radiolaria exists to my knowledge, and, although the most admirable monograph of Professor Haeckel was at the time (1862) a complete and exhaustive account, yet were it even readily and generally accessible, important additions have now been made to our knowledge of these animals since its publication. I venture to think therefore that an account of these beautiful, and in many respects complex organisms, will not be an unwelcome addition to English zoological literature."

The paper commences with a general descriptive account of the Radiolaria, followed by observations on their impressionability, locomotion, and nutrition; reproduction and growth; zoospores (with and without crystals); modes of growth; distribution; classification, and literature.

In concluding the descriptive part of his subject, the author says that "to his mind it seems evident that these beautiful symmetrical and complex forms cannot be due to the action of *natural selection*, and *sexual selection* can of course take no part in forming such organisms as these. We seem here to have forced upon our notice the action of a kind of organic crystallization, the expression of some as yet unknown law of animal organization here acting untrammelled by adaptive modifications or by those needs which seem to be so readily responded to by the wonderful plasticity of the animal world."

The multicellular nature of Radiolarians, it is pointed out, now depends entirely on the normal nature of their yellow cells, and on the correctness of the observations as to the centripetal cell-groups of *Physematium.* Neither of these phenomena can be reposed on as being certainly of the nature of true cells forming part of the normal organization of the Radiolarians in which they have been found; but even if they are so, and if we are compelled therefore to regard Radiolarians as multicellular, their multicellularity is of a radically different kind from that of any of the Metazoa, and none of their parts, whether truly cells or not, have any valid claim to the denomination of a tissue.

In regard to the relations of the Radiolaria to the other Protozoa, it is at present a disputed question whether it is the more natural arrangement to make on the one hand the Heliozoa, Radiolaria, and Thalamophora three distinct and coequal equivalent groups, or on the other hand to form two great groups, the one containing, as two subdivisions, the Heliozoa and Radiolaria, and the other the marine and fresh-water Thalamophora. On the whole, notwithstanding undeniable similarities in external form, chemical composition, and otherwise, the author is inclined to keep the Radiolaria and Heliozoa provisionally apart as two equivalent and divergent groups, though unquestionably of all the above Protozoa the Heliozoa come nearest to the Radiolaria. The distinctions which seem to justify this are:—

	Radiolaria.	Heliozoa.
(1)	A porous capsular membrane present.	Absent.
(2)	A gelatinous investment present.	„
(3)	Reproduction by numerous zoospores, each with a nucleus and flagellum, but with no vacuoles.	The much fewer separated reproductive parts have each two flagella, several contractile vacuoles, and a nucleus with vacuoles and nucleoli.
(4)	Yellow cells present in almost all.	Absent.
(5)	Entirely marine.	Almost entirely fresh water.
(6)	——	Pseudopodia often with axis-fibre.

The author observes, however, that (5) is much weakened by the discovery of the salt-water Heliozoa; that with regard to (3), though the differences which exist between the reproductive processes are very great, yet greater differences exist between different Heliozoa, while the reproductive processes of so few Radiolarians have been examined that it would be rash to feel confident that no important divergences will be hereafter found amongst them in this respect, and that as to the capsule the distinction would be weakened if it should turn out that young Radiolarians, which have not yet acquired a capsule, nevertheless show a differentiation of their sarcode into an inner and an outer layer, like the medullary and cortical parts of Heliozoa, and the distinction would be broken down if it should be shown that certain adult Radiolarians have no capsule at all.

In dealing with the classification of the group the author suggests considerable modifications upon that of Haeckel. He objects (as unnatural) to Haeckel's division of the group into Monozoa or Monocyttaria and Polyzoa or Polycyttaria, the aggregation or non-aggregation of zooids into colonies being, in his opinion, a comparatively unimportant distinction, especially as individual zooids of the compound species are found also in a single and separate condition, and he suggests the union of Haeckel's fifteen groups into larger aggregations, reducing them to seven. These are:—

VESICULATA.—Formed by separating from Haeckel's COLLIDA those forms (viz. *Thalassicolla*, *Thalassolampe*, *Aulacantha*, and *Physematium*) which have a nuclear vesicle—the presence or absence of which the author, following Hertwig, considers as of greater importance as a classificatory character than any characters derived from the skeleton—and uniting them with his AULOSPHÆRIDA and the other genera (*Heliosphæra* and *Diplosphæra*, part of his ETHMOSPHÆRIDA and the new form *Myxobrachia*), which possess that structure.

COLLOZOA.—Formed of the remaining COLLIDA (*Thalassosphæra* and *Thalassoplancta*) and Haeckel's SPHÆROZOIDA and COLLOSPHÆRIDA (which constitute his Polycyttaria).

POLYCYSTINA.—Formed of Haeckel's ACANTHODESMIDA and CYRTIDA, and the rest of his ETHMOSPHÆRIDA, associated together as being ectolithic, non-vesiculate, simple forms, the skeleton of which consists of more than detached spicula.

FLAGELLIFERA.—Formed of the genera *Spongocyclia* and *Spongoastericus* (part of Haeckel's SPONGURIDÆ) and *Euchitonia*, a genus of his DISCIDA—the possession of a large flagellum being, the author considers, a very important and natural character.

ACANTHOMETRIDA.—Formed by adding to the similarly named group of Haeckel those of his OMMATIDA (*Dorataspis* and *Haliommatidum*), whose radii meet together in the centre of the capsule—a very special and peculiar condition—and the author regarding as unnatural the separation from Haeckel's ACANTHOMETRIDA of these latter forms, which differ only in having tangential outgrowths from their radii so disposed as by their mutual junction to form an external shell. Haeckel's DIPLOCONIDA being also added as a third sub-section as presenting the special character of centrally-joined radii, regarding its conical structure as a mere special modification of radial structure.

ENTOSPHÆRIDA.—Comprising the remainder of Haeckel's OMMATIDA and part of his SPONGURIDA (*Dictyoplegma*, *Spongodictyum*, *Rhizosphæra* and *Spongosphæra*), the latter being an unnatural group, the possession of a spongy skeleton existing in very different forms. Adding also his CLADOCOCCIDA and CŒLODENDRIDA as forms possessing an intracapsular, more or less spheroidal shell—the latter from its exceedingly noteworthy mode of growth—by absorption and redeposition—possibly being entitled to be made a distinct primary group.

DISCIDA.—Comprising the group so named by Haeckel (except *Euchitonia*) with the rest (*Spongodiscida* and *Stylospongia*) of his SPONGURIDA and his LITHELIDA.

The sections will then stand thus:—

I. Discida.—Mostly discoidal, sometimes elliptical, rarely cylindrical or spheroidal. Skeleton in part intracapsular, and consisting always of both circumferential and radial parts, which may be quite irregularly disposed, but which properly form an external, perforated shell, with an internal partition or spheroidal mass, forming a series of mutually communicating chambers, which are either concentrically or spirally arranged. No flagellum. Growth, multipolar or centrifugal. No nuclear vesicle.

II. Flagellifera.—With a flagellum. No nuclear vesicle.

III. Entosphærida.—With an intracapsular spheroidal shell; not traversed by radii. No nuclear vesicle.

IV. Acanthometrida.—With radial skeleton, the radii of which meet in the centre of the capsule, and consisting more or less of acanthin. No nuclear vesicle. Yellow cells generally absent.

V. Polycystina.—Simple, ectolithic forms, with more or less compact skeletons, often with unipolar growth. No nuclear vesicle.

VI. Collozoa.—Simple or compound. If single, then with the skeleton in the form of circumferential detached specula only. No nuclear vesicle.

VII. Vesiculata.—With a nuclear vesicle.

Oblique Light for Photo-micrography.—In a letter written by Dr. Woodward to M. Deby, the Vice-President of the Belgian Microscopical Society, in September last, he describes the method he makes use of when it is necessary in photo-micrography to use very oblique light, as in the case of Nobert's test, *Amphipleura pellucida*, &c. A pencil of parallel solar rays (reflected by the heliostat and plane mirror) is intercepted by the cell containing the solution of ammonio-sulphate of copper and a diaphragm which only allows the passage of a circular pencil of ½ inch in diameter. The light enters parallel to the optic axis of the microscope placed horizontally and on the same level, but at a lateral distance (either right or left) of 3 inches. If the light is intercepted by a large achromatic prism of a focal length of about 3 inches, the desired obliquity can be obtained without difficulty. It is indispensable that the stage of the microscope should be very thin, or otherwise a false stage must be adopted like that supplied by Powell and Lealand. The best result is obtained when the rays are concentrated to a focus on the object itself. The illumination thus obtained is in general sufficient to produce negatives by the wet process up to 2500 diameters with three minutes' exposure.*

The Birth of a Rhizopod.—Professor Leidy has made some observations on this subject, which he records in the 'Proceedings of the Academy of Natural Sciences of Philadelphia':—

I have long sought for the mode of multiplication of the test-covered Rhizopods, but thus far with little success. It appears as if the different forms with which we meet are always mature, and rarely are individuals seen with the ordinary characters which distinguish young from adult animals.

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* 'Bulletin de la Société Belge de Microscopie,' vol. iv. p. 61.

Recently I observed a pair of conjoined individuals of *Euglypha alveolata*, which in their procedure appeared to coincide with the mode of multiplication of *Chlamydophrys stercorea* as described by Cienkowski. One of the *Euglyphæ* was one-seventh of a millimetre long (0·14 mm. long, 0·068 mm. in the short diameter), and had four long spines diverging from the fundus of the test. This was replete with the contents, including the usual large nucleus; and it presented no perceptible interval between the mass of sarcode and the interior surface of the test. The sarcode was mingled throughout with particles of food, and also included a large *Navicula*. The food was not collected in balls contained in vacuoles, but was diffused through the sarcode from the mouth to the fundus of the test, imparting to it a brownish hue. The globular nucleus measures $\frac{1}{25}$ of a millimetre.

Closely adherent to the mouth of the larger or parent *Euglypha* was the smaller or younger one, little more than half the size of the parent (measuring 0·08 mm. long and 0·06 mm. wide). The young *Euglypha* had the fundus somewhat abruptly narrowed and acute, and projecting from it the same number of spines as in the parent test. The peculiar structure of the test was apparent, but appeared less extended or unfolded. The contents filled the test, and consisted of clear, colourless, finely granular protoplasm, without any mixture of food, and without a nucleus.

Such was the appearance of the conjoined *Euglyphæ* parent and offspring at the commencement of the observation at 6¼ o'clock in the morning.

Closely watching the pair, the young *Euglypha* was noticed slowly to enlarge, and the brownish matter of the parent sarcode gently flowed into and became gradually diffused with the previously clear, colourless sarcode of the child. The fundus of the latter extended and became obtusely rounded, like that of the parent. The large nucleus of this disappeared or became so completely obscured as not to be visible. For some time there was no further very perceptible change within either test.

An hour from the commencement of the observation the young *Euglypha* had nearly acquired the size, shape, and appearance of the parent, and it measured 0·112 mm. long and 0·064 mm. broad. Now commenced an active circulation, a cyclosis, of the contents of the two tests, resulting in a thorough admixture. The sarcode flowed continuously from the parent on one side through the mouths into the child, and back again on the other side. Both tests were replete with one continuous mass of brown granular sarcode without nucleus or contractile vesicles, but with the *Navicula* which remained within the parent. During the circulation of the sarcode, two of the spines with the circular scale at their base became detached from the young *Euglypha*. The circulation ceased. At 7½ o'clock I first observed the appearance of a contractile vesicle, 0·016 mm. in diameter, at the fundus of both animals. The vesicle collapsed and reappeared in two, three, or four, each again successively collapsing. With the appearance of the contracting vesicles the contiguous sarcode began to clear up the brownish matter accumulating in advance of the usual position of the nucleus when present.

At this time the young *Euglypha* measured 0·116 mm. long and 0·064 mm. broad.

The sarcode of the parent now contracted at the middle, leaving a space between it and the test. The same change occurred in the child. The sarcode of the parent next cleared up in the vicinity of the mouth, then separated from that of the offspring, and retracted a short distance within the mouth.

At 5 minutes to 8 o'clock the two *Euglyphæ* bent slightly from side to side, protruded delicate pseudopods, and in two minutes afterwards were completely separated, with their mouths directed downward, and their fundi turned towards my eye.

Half an hour after separation a pale nucleus had made its appearance in both individuals, occupying the usual position, and measuring 0·028 mm. in diameter. Two or more contractile vesicles disappeared, and reappeared around the position of the nucleus. While the parent retained the original size, the young *Euglypha* was 0·12 mm. long by 0·064 mm. broad.

From this observation of the mode of multiplication of *Euglypha*, coupled with that of Cienkowski on the multiplication of *Chlamydophrys*, it may be inferred that all the test-bearing Rhizopods multiply in a similar manner.

The mode of multiplication of these Rhizopods reminds one of the mode of production by division of the Desmids, and in observing the process in the *Euglypha* I was forcibly struck with its resemblance to the mode of production of *Arthrodesmus octocornis.* The production of the young Rhizopod would correspond with that of a half cell of a Desmid.

Apparent Discriminative Power in the Selection of Food by a Heliozoon.—Professor Leidy also stated to the Academy that he had on several occasions observed actions in the Rhizopods apparently indicating a discriminative power in the selection of food. It was certain that they generally swallowed living Algæ and Animalculæ, and avoided dead ones. He recently had observed a Heliozoon eject an article which appeared to indicate a discriminative power. The Heliozoon was *Acanthocystis spinifera.* The genus differs from *Actinophrys* in being provided with siliceous rays in addition to the ordinary soft rays. The former emanate from minute disks, forming as it were a sort of flexible armour to the body of the *Acanthocystis.* While examining an individual, a rapidly moving oval flagellate Infusorium, as it was supposed to be, came into contact with several of the soft rays. The Infusorium was paralyzed; it assumed a globular shape and became quiescent. It was gradually drawn towards the body of the Heliozoon, which projected its armour to meet it, but quickly withdrew it again, and the Heliozoon was pushed off beyond the siliceous rays. The same movements were repeated, and then the Infusorium remained outside the siliceous rays. The objects were examined from time to time for several hours. The Infusorium was no more drawn towards the body of the Heliozoon. After a time it projected a minute bud, which gradually extended into a tortuous tube, proving the supposed Infusorium to be a zoospore. It was finally abandoned by the Heliozoon, apparently as if it had been determined not to be its proper food.

On the Feeding of Dinamœba.—These curious amœboid animals take their food at what may be considered the posterior part of the body, and one instance, observed by Professor Leidy, appeared to him to be particularly interesting, and was related as follows:—Seeing a specimen of *Dinamœba* with its left side in contact with a filament of the Alga *Bambusina Brebissonii*, he was led to watch it. On closer examination it proved that the Alga entered to the left of the tail, and extended through the body, causing a slight bulge of the ectosarc by its other end to the left of the head. The *Dinamœba* became slightly elongated, and the Alga sunk more inwardly from behind. The former moved with an inclination to the right, causing the Alga to assume an oblique position from left to right. The anterior end of the Alga suddenly protruded from the body of the animal, so that this appeared to be pierced by it. In this condition the Alga entered the *Dinamœba* to the left of the tail and protruded at the right of the head. Gradually the Alga was made to assume a transverse position. The right extremity of the Alga now became depressed and the left elevated, so that the Alga assumed nearly its original position, in which it appeared to perforate the left border of the animal obliquely from the tail end. It gradually acquired a central position, penetrating the animal from tail to head. The *Dinamœba* now elongated at both ends a third greater than its former length, extending in a fusiform manner upon the Alga. The animal next doubled upon itself, so that both ends of the Alga approached in front and protruded side by side from the head. One extremity of the Alga then sank within the *Dinamœba*, and subsequently the other extremity, so that the filament about three times the length of the animal became coiled up within it.

The observation of swallowing the *Bambusina* was made in the afternoon. In the evening, several hours after the first observation, on looking at the *Dinamœba* which had been preserved in an animalcula cage, it was observed sitting as it were on a large filament of the Alga *Didymoprium Grevillii.* The posterior end of the animal extended as a cylindrical expansion along the Alga to a greater length than the breadth of the body of the *Dinamœba*, and so closely clasped it as to contract the gelatinous envelope of the Alga to little more than the thickness of the green cells. After some time the Alga suddenly broke, and the two portions were gradually bent backwards, and made slowly to approach so as to become parallel with each other. One of the pieces was then drawn within the animal a convenient length, broken off and completely swallowed, and this was followed by a similar movement of the other piece. Shortly after the first rupture of the Alga, when the two portions projected at an obtuse angle from the back portion of the *Dinamœba*, the animal contracted in length and discharged from the right side a mass of bodies which consisted of the separated cells of *Bambusina*, probably from the filament it had swallowed in the afternoon.

These observations apparently explained certain facts in the habits of the animal. *Dinamœba* had been noticed to be especially fond of the Alga *Didymoprium*, for it was found to be present as the principal element of the food in numerous specimens. *Bambusina* was less frequently found among the food contents of the animal. The Algæ were equally abundant in the localities of the *Dinamœba*, and from the observations detailed it would appear that the *Didymoprium* is preferred as food from the comparative ease with which its filaments are broken into pieces of convenient size for swallowing.

The observations are, moreover, interesting from their indicating discrimination and purpose in the movements of one of the simplest forms of animal life. The movements are to be viewed as reflex in character, though resembling the voluntary movements by which the most intelligent animal would prepare morsels of food of convenient form to take into the mouth. In striking contrast were the movements, noticed on several occasions, by which an *Oscillatoria* obtained entrance into the empty shell of an *Arcella*, and there, coiled up, crept round and round incessantly.

On the Measurement of the Dihedral Angles of Microscopic Crystals.— M. Em. Bertrand has communicated the following to the French Academy:—

The goniometer of Wollaston, more or less improved, is the only apparatus now employed for the exact measurement of the dihedral angles of crystals, and with this instrument in its present condition very small crystals can be measured. There is, however, a limit beyond which it becomes insufficient, and a crystal whose sides are for instance only the thirtieth of a millimetre cannot be measured by means of it. A method which would allow the dihedral angles of microscopic crystals to be measured, presents therefore some interest, for the crystals are generally purer the smaller they are.

For this I have endeavoured to make use of the microscope, but the difficulty which was at once presented was the orientation * of the crystal to be measured. By means of the procedure explained below, this orientation becomes useless, and we are able by an indirect process to calculate the angle of the two faces of a crystal without it being necessary to orient it.

Take a cube and place a crystal in any position on one of the faces of it. Suppose one of the faces of the crystal to be prolonged to meet the face of the cube on which it is placed, the projection of this face of the crystal on the face of the cube will form with two of the edges of the cube two plane complementary angles. If we suppose this face of the crystal prolonged beyond the face of the cube on which it is placed, we shall obtain upon two other faces of the cube two projections, making respectively, with two edges of the cube, plane complementary angles, and the direction of the face of the crystal will be

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* This word may well be adopted into the English vocabulary.

determined by reference to the edges of the cube if the three plane angles are known which the three projections of the face of the crystal make with the three edges of the cube. Two plane angles even are sufficient, for the third can be calculated from the first two by the simple formula

$$\tan. a = \cot. b \cot. c\,;$$

a, b, c being the plane angles which the three projections of the face of the crystal make with three edges of the cube meeting at the same summit.

A second face of the crystal will be equally determined as regards its direction, by the three angles α, β, γ, these three angles corresponding to the angles a, b, c, of the first face of the crystal, as was said above.

It follows therefore that if the three angles a, b, c, are known, or two only of those angles, and the three angles α, β, γ, or two only of those angles, we can calculate the dihedral angle of the two faces of the crystal by the formulæ

$$\cos. x = \frac{\cos. y \sin. (z - \phi)}{\sin. \phi}, \quad \cot. \phi = \tan. y \cos. (b + \beta),$$

$$\tan. y = \frac{\tan. a}{\cos. b}, \quad \tan. z = \frac{\tan. \alpha}{\cos. \beta}.$$

If x is indeterminate, it can be calculated by the formulæ

$$\sin. \tfrac{1}{2}\, x = \frac{\cos. \frac{1}{2} (y + z)}{\cos. \omega}, \quad \tan. \omega = \frac{\sin. \frac{1}{2} (b + \beta)}{\cos. \frac{1}{2} (y + z)} \sqrt{\sin. y \sin. z}.$$

It only remains then to point out a practical means of measuring the angles a, b, c, α, β, γ.

I place in the eye-piece of a microscope a cylinder of flint glass whose index of refraction is greater than that of Canada balsam. This cylinder (the two bases of which are exactly parallel) is divided in halves by a plane perpendicular to the bases; the two rectangular faces are polished and fixed together again by Canada balsam. This cylinder is placed in the eye-piece so that its upper base is in the focus of the upper lens of the eye-piece, the two bases being perpendicular to the optic axis of the microscope, and the median plane of the cylinder passing through the optic axis and through the zero of the division of the revolving stage.

Under these conditions if the microscope receives the light in a direction parallel to the median plane of the cylinder, an illuminated field will be seen crossed by a line forming a reticle; but if the microscope receives the light obliquely to the median plane of the cylinder, the reticle will be seen to divide into two, and if the eye is inclined to the right or the left, the reticle will be bordered on one side by a black band of greater or less breadth, and on the other side by a bright band, this phenomenon being produced by the total reflexion which the luminous rays experience in traversing the cylinder obliquely and meeting the layer of balsam whose refractive index is less than that of the flint.

Consequently, if the reflecting face of the crystal has its projection perpendicular to the zero line of the microscope, a reticle will be seen equally illuminated to the right and left; but if the crystal is turned with the stage of the microscope, the reticle immediately becomes bordered on one side by a black band and on the other by a bright band. By placing the cube on the stage of the microscope, on its different faces in succession, it is easy to measure the angles which the projections of the faces of the crystal make with the edges of the cube, and it is seen that, however small a crystal may be, the phenomenon above described will be produced, provided that the crystal is able to reflect the light over a space sufficiently large to illuminate the centre of the reticle. It is sufficient that the face of the crystal should be about two millimetres, but a crystal of a thirtieth of a millimetre can be measured with an enlargement of only sixty diameters. A crystal of $\frac{1}{100}$ of a millimetre would require an enlargement of two hundred times.

In order to allow each face of the crystal to be placed successively in the axis of the microscope without changing the relative directions of the faces of the crystal, the edges of the cube, and the divisions of the stage, it is necessary to adapt to the revolving stage another stage movable in two rectangular directions by means of two micrometric screws, or, for more precision, to have a micrometric screw for the rotating movement.

To appreciate the degree of precision which this method gives, I have measured crystals of less than $\frac{1}{30}$ of a millimetre, such as the cleavages of spar, of blende, and of the microscopic crystals of quartz, and the error has never exceeded one degree.

This error is great, but these first attempts have been made with an eye-piece which is still imperfect, and I have not kept to the conditions of illumination which are necessary to obtain the best possible effect. I am convinced that, with slight modifications, great exactitude can be attained.

I have in view another system of eye-piece, also based on total reflexion, which ought to be still more sensitive than the system which I have just described, but not having yet experimented upon it, I abstain from describing it. The improvements which I have in view will, if they answer, form the subject of a further communication.*

The Microscopic Structure of the Stromatoporidæ, and on Palæozoic Fossils mineralized with Silicates, in illustration of Eozoon.—Principal Dawson communicated a paper on this subject to the Geological Society, which was read at the meeting of the 5th June:—The fossils included in the group Stromatoporidæ occur from the Upper Cambrian to the Upper Devonian inclusive, and are especially abundant in the Trenton, the Niagara, and Corniferous formations. The author regards *Stromatopora* as a calcareous, non-spicular body, composed of continuous, concentric, porous laminæ, thickened with supplemental deposit, and connected by vertical pillars, most of which are solid. The surface shows no true oscula; but perforations

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* 'Comptes Rendus,' vol. lxxxv. p. 172.

made by parasitic animals have been mistaken for such. From the structure they could not have been related either to Sponges or to *Hydractiniæ*, and still less to Corals; they are truly Foraminiferal, and may be regarded as the Palæozoic representatives of *Eozoon*. *Stromatopora* occurs infiltrated with calcite or silica, or with its structure wholly or in part replaced by crystalline silica or dolomite. The author concluded his first section with the characters of the genera which have been included in the Stromatoporidæ.

In the second part he noticed a number of facts relating to the occurrence of hydrous silicates, of the nature of serpentine and loganite, infiltrating Palæozoic fossils and illustrating the mode of occurrence and mineralization of *Eozoon*. Instances of this kind were said to be exceedingly common, showing that such silicates, whether originating as direct deposits from water, or as products of the decomposition of other minerals, are efficient agents in the infiltration of the pores and cavities of fossils, and have played this part from the earliest geological periods.

A Microscopical Study of some Huronian Clay-slates.—At the meeting of the 19th June, a paper by Dr. Arthur Wichmann was also read, of which the following is an abstract:—Although a considerable amount of attention has been devoted during recent years to the microscopical study of clay-slates and slate-clays, yet in none of the published researches on this subject has any account of the structure of the clay-slates of Archæan age been given. The author has availed himself of the extensive series of Huronian clay-slates collected by Major T. V. Brooks in the country around Lake Superior to supply this deficiency. The succession and relation of the rocks described have been fully treated of in the work of Hermann Credner and the publications of the Geological Survey of Michigan.

The chief object of the author is to discuss the origin of the crystalline constituents in clay-slates, and at the outset he describes in detail the microscopical character of clay-slate, of novaculite or whetstone, and of carbonaceous shales and slates respectively, dwelling more especially on the crystallized minerals which can be detected in each of these rocks, and the nature of the isotropic ground-mass which sometimes surrounds them. He then points out that three theories have been advanced to account for the presence of these crystalline constituents in clay-slates. According to the first of these theories, the crystals in question are regarded as the product of chemical action in the ocean in which the original material was deposited. The second theory attributes the formation of the crystalline minerals to processes of metamorphism which have taken place subsequently to the solidification of the rocks. The third theory refers them to aggregative action going on in the still plastic clay-slate mud prior to its solidification. The first of these theories has been maintained by G. R. Credner, but against it the author adduces numerous arguments, and especially points out the difficulty of supposing an ocean capable of depositing from its waters at successive periods minerals of such different chemical composition as chlorite, actinolite, &c. In opposition to the second theory, which has received the support of Delesse, the author points out the existence in the rocks in question of broken crystals, which have been recemented by the surrounding clay-slate substance. The author is thus led to incline towards the third theory, in favour of which some striking facts, drawn from the microscopical structure of the rocks, have already been adduced by Zirkel. He admits, however, that later metamorphic actions are not to be excluded in seeking to account for the origin of the crystalline constituents of clay-slates, and points out that four distinct stages must be considered in the series of changes by which the rocks in question have acquired their present character:—1st, the deposition of the mud; 2nd, the formation of minerals during the plastic state; 3rd, the separation of materials during solidification; and 4th, the action of metamorphic processes.

Preparations of Infusoria, &c.—Professors Cohn (of Breslau) and Stein (of Prague) commend a new process, discovered by Herr Duncker of the "Microscopic Institute" of Berlin, "after a series of long-continued and laborious researches, for preserving with the greatest possible truth to nature even the most delicate aquatic microscopic organisms, including many whose production has been hitherto considered an impossibility:" these include Confervæ, Desmidiæ, and Diatoms (with the organic parts preserved in their integrity), Rhizopods (Amœbæ, &c.), Flagellata (Volvox, Cryptomonads, Astasiæ), Cilio-Flagellata, Ciliata, Rotifers, Entomostraca (Cyclops, and particularly Daphnia, with the utmost possible preservation of the soft parts), Tardigradia, and Larvæ. It is suggested that such preparations will facilitate the determination of the microscopic fauna and flora of particular localities.

The Binocular with High Powers.—Suggestions have recently been revived in American and English journals that Wenham's ordinary binocular prism can be effectively used with the highest powers, inasmuch as by special modes of illumination—either by duplicating the light or directing it from two positions at a greater angle, as with a second mirror, the Paraboloid, or Powell and Lealand's condenser—the two fields may be obtained free from any defect of light at the outer margin, both with a $\frac{1}{6}$, an $\frac{1}{8}$, or even a $\frac{1}{12}$ object-glass. In regard to this, Mr. Wenham writes that "his own opinion of the binocular microscope, in any form where the result is obtained from half the object-glass, is that in powers higher than one-fifth it ceases to be of much utility, as the combined images cannot compensate for *the loss of definition in each eye.* In the form of prism by means of which the full aperture is obtained in each eye with equal illumination in both tubes, the effect is much superior, and in lengthened observations with either high or low powers it affords great relief to be enabled to use both eyes continuously without regard to any special mode of illumination."

The Germ Theory of Disease.—The number of the Linnean Society's Journal issued on 23rd May,* contains the concluding portion of Dr. Bastian's now familiar experiments with urine and potash, and

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* Vol. xiv., No. 74.

includes his observations on the germ theory of disease. The author considers that "by his experiments, in addition to the disproof of a false hypothesis, he has unquestionably done one or other of two things: either (*a*) he has proved that living matter may be now evolved *de novo*, or (*b*) he has succeeded in bringing back to life germs which hitherto were so powerless and latent as to have been regarded by other experimenters as hopelessly dead. Even the latter is no mean result for the physician and the science of medicine, since the question of the truth or the reverse of the 'germ theory of disease' is thereby almost as powerfully influenced as if the former alternative had been established with complete certainty. . . .

Though it may be conceded that with our present state of knowledge an affirmative decision in regard to the absolute proof of the present occurrence of Archebiosis may be still withheld, there is no similar warrant for suspense of judgment in regard to the germ theory of disease, or, as it is also called, the doctrine of contagium vivum. Existing evidence is abundantly sufficient for the rejection of this doctrine as untrue; and from the evidence, more or less fully referred to in the paper, it seems to him legitimate to conclude:—

First, that if we are to be guided by the analogy now dwelt upon as existing between fermentation and zymosis, it would be perfectly certain that the latter process can originate *de novo*, that is, under the influence of certain general or special conditions, and where specific contagia of any kind are at first absent, though they subsequently appear as results or concomitant products. So that an exclusive theory of 'contagion,' as the only present cause of communicable diseases, is not supported by experimental evidence.

Secondly, that some contagia are mere not-living chemical principles, though others may be living units.

Thirdly, that even in the latter case, if the primary contagious action be really due to the living units, and not to the media in which they are found, such primary action is probably dependent rather upon the chemical changes or 'contact actions' which they are capable of setting up, than upon their mere growth and vegetative multiplication.

Fourthly, that where we have to do with a true living contagium (whether pus-corpuscle or ferment organism), the primary changes which it incites are probably of a nature to engender (either in the fluids or from the tissue-elements of the part) bodies similar to itself, so that the infected part speedily swarms therewith. When pus from a certain focus of inflammation comes into contact with a healthy conjunctiva, and therein excites a contagious form of inflammation, no one adopts the absurd notion that all the pus-corpuscles in this second inflammatory focus are the lineal descendants of those which acted as the contagium; and the mode of action may be altogether similar when the matter containing Bacilli, by coming into contact with a wounded surface, gives rise to splenic fever and the appearance of such organisms all through the body. The old notion about the excessive self-multiplication of the original contagium is probably altogether erroneous. Thus all the distinctive positions of those who advocate a belief in the so-called 'germ theory of disease,' or rely upon the exclusive doctrine of a 'contagium vivum,' seem to be absolutely broken down and refuted. We may give that attention to the appearance and development of independent organisms in association with morbid processes which the importance of their presence demands, but we must regard them as concomitant products, and not at all, or except to any extremely limited extent, as causes of those local and general diseases with which they are inseparably linked."

Hydroida of the Gulf Stream. — Dr. Allman's Report on the Pourtalès Collection of Hydroids from the Gulf Stream describes a very large number of new and interesting forms, and is one of the most important contributions to their natural history that has appeared of late years. It is illustrated by thirty-four plates.

A Water-lens Microscope.—Mr. G. M. Hopkins, in the 'Scientific American,' describes a microscope which, it is claimed, "renders a drop of water available as a microscope lens by confining it in a cell, thus obviating the tremor of the early water microscopes, a defect which rendered them almost if not quite worthless." The cell consists of a brass tube $\frac{3}{8}$ inch long and $\frac{1}{8}$ to $\frac{3}{16}$ inch internal diameter, blackened, with a thin piece of glass cemented to the lower end, and having in one side a screw for displacing the water, to render the lens more or less convex. Several bushings may be fitted to the upper end of the cell to reduce the diameter of the drop, and thus increase the magnifying power of the lens.

The Structure and Development of Sponges. — In Siebold and Kölliker's 'Zeitschrift f. wiss. Zoologie,' vol. xxx. part 4, is an article "On the Structure of *Reniera semitubulosa:* a Contribution to the Anatomy of the Siliceous Sponges," by Dr. E. Keller. Mr. E. Ray Lankester, in a 'Biological Note' contributed by him to 'Nature' of July 18, gives the following summary of the article, with additional observations of his own:—

The sponges are at present attracting a very large amount of attention from zoologists and are undergoing investigation in the fresh condition, so that their living soft tissues are subjected to the refined methods of modern histology. Professor Franz Eilhard Schulze, of Gratz, is foremost in this study, the way in which was led by Ernst Haeckel in his monograph of the Calcispongiæ. Dr. Keller, of Zürich, who has previously published on the development of certain calcareous sponges, has now given attention to *Reniera semitubulosa*, O. Schm., a representative of the commoner marine fibrous sponges. Schulze, by the use of silver nitrate, discovered a differentiated epithelial covering to the body surface, which was previously denied by Keller, who now admits Schulze's observation to be correct, and adds a similar observation of his own on Reniera. Keller describes the syncytium of Reniera, denies the existence of muscular cells, and recognizes certain "nutritive wander-cells" in the body-wall of the sponge. His observations on "starch-containing cells" are of special importance. He was led to attach a high functional importance to the nutritive wander-cells which pass inwards from the flagellate endoderm-cells, carrying with them assimilated matter necessary for the nutrition of the syncytium, which forms a thick wall beyond. His conception of their importance was confirmed by the discovery that many of them contain starch. Keller has made an extensive search for starch in the cell-elements of sponges, and has found it, or rather we should say has obtained the blue reaction with iodine, in cells from the following sponges:—(1) *Spongilla lacustris*, (2) *Reniera litoralis*, nov. spec., (3) *Myxilla fasciculata*, (4) *Geodia gigas*, (5) *Tethya lyncurium*, (6) *Suberites massa*, (7) *Suberites flavus*. The substance, whatever it may be, which gives the blue reaction, is not in a granular condition, but fluid, and in those cells in which it occurs occupies a large vacuole comparable to a fat-vacuole. Neither ordinary nor absolute alcohol, nor cold water, dissolve the contents of this vacuole. Keller could not find this starch-like substance in Halisarca nor Chondrosia, nor in any Calcispongiæ. It seems desirable in this connection to refer to the strictly granular condition in which chlorophyll appears in the case of Spongilla, the granules having the form of concavo-convex disks. In colourless (etiolated) specimens of Spongilla, the same granules are present of a little different form, and as in Neottia and other similar plants, these granules turn green (develop into chlorophyll?) on the addition of strong sulphuric acid (see 'Quarterly Journal of Microscopical Science,' 1874, vol. xiv. p. 400, where I have recorded these facts, and also that of the occurrence of starch in Spongilla, though I have not yet been able to find the authority for the latter observation, which was made many years previously to Keller's investigation). With regard to the question of the formation of a gastrula in sponges, and as to the development of the endoderm of that gastrula into the endoderm of the adult sponge, and therefore the continuity of the archenteric cavity of the gastrula with the digestive cavity and canals of the sponge, Keller has some remarks to offer which do not, in point of fact, amount to very much. Like Franz Eilhard Schulze, Keller fell into a complete error in his earlier publication on the development of calcareous sponges. Haeckel, in his monograph, stated that the sponge embryo was at first a hollow one-cell-layered sac, on the inner wall of which a second cell layer formed, by delamination, whilst subsequently a mouth broke through. This was vehemently denied and ridiculed by Metchnikoff; it was also denied by Oscar Schmidt, and by F. E. Schulze, who published a beautiful set of drawings showing that after the embryo sponge had acquired some thirty or forty cells, one hemisphere of cells became granular and enlarged, and then invaginated—sunk into the other hemisphere—thus forming a gastrula with endoderm and archenteron by invagination. This account was at first accepted as the true one, but it was strongly insisted upon by Keller in his former memoir, that the orifice of invagination closes up, as in fact the blastopore so usually does throughout the animal kingdom, and that the young sponge is then a mouthless closed sac with two layers of cells. It was in this condition that Haeckel saw it and described the further stage in which the true mouth breaks through. There is, however, still a great difficulty about the development of the gastrula of sponges; for no one can doubt, who will examine a common calcareous sponge, or who looks at Barrois' valuable memoir on the subject, that F. E. Schulze was—as he himself has admitted—so far misled in his account of the development of *Sycandra rœphanus* as to transpose two very important stages of the development. In fact, the concavo-convex stage of the embryo sponge, with one set of cells (endodermic) tucked into the narrower, clearer, longer, ciliate cells, actually *precedes* that in which the same cells form respectively a hemisphere of clear ciliate cells and a hemisphere of large swollen cells, not tucked into the former at all, but so arranged that a small central cavity is closed in by the two groups. How we pass from this stage to the young sponge, or even to the two-cell-layered sac, is still a complete mystery. One thing, however, is obvious. Haeckel could hardly have been led to the generalization known as the gastræa theory, which, on the whole, is a truthful and productive generalization, by erroneous observation. We must, therefore, respect his positive statements of fact.

The Eyes of Insects.—In a paper by Mr. B. T. Lowne, on "The Modifications of the Simple and Compound Eyes of Insects," read before the Royal Society, the author states that in his opinion the extent and curvature of the cornea and the size and curvature of the facets afford the most important indications as to the manner in which vision is accomplished. In the true compound eye, he thinks the structure indicates that J. Müller's theory of vision is the most probable; this is also Dr. Grenacher's view, and it is supported by the curvature of the cornea and the size of the corneal facets in different insects, as well as in different parts of the same eye.

The semi-compound eye introduces no new difficulty in this theory.

In order to determine the effect of the long, fine, highly refractive threads of the eyes of insects upon the light, he made some experiments on the transmission of light through fine threads of glass.

He took a capillary tube of glass $\frac{1}{500}$ of an inch in thickness, about $\frac{1}{100}$ of an inch in diameter, and an inch in length, placed it upright in a small trough under the microscope and examined it with an inch objective. He found that no light passed through the lumen of the tube, but that the section of the wall of the tube appeared brightly illuminated. He next placed a few fine glass threads, drawn from a glass rod, in the interior of the tube; these were as nearly as possible the same length as the tube and measured $\frac{1}{1000}$ of an inch in diameter. The upper end of each of these rods appeared as a brightly illuminated disk in the dark field; when the focus of the microscope was altered, the disk was enlarged, showing that the rays left the rod in a divergent direction; in some cases when the ends of the rods lay beyond the focus of the microscope, the disks of light exhibited grey rings, the result of interference.

When the lower ends of these rods were lenticular, or fused into a drop, or drawn into a core, the phenomena were the same, and in all cases the action of an oblique pencil, even when the obliquity was very slight, was feeble as compared with that of a pencil having the direction of the axis of the rod.

These results are such as would be predicted on theory; all the light passing into the rod, except very oblique rays, would be totally reflected, without any change of phase in the undulations, at the surface of the glass, whilst all except the axial rays would be very much enfeebled by numerous reflexions and interference from the different lengths of the paths of the rays. In his opinion, threads of a highly refractive character immersed in a medium of a less refractive index, when less than $\frac{1}{5000}$ of an inch in diameter, would destroy the effect of rays of only very small obliquity by interference.

In order to determine the effect of the pigment, he covered the exterior of some glass rods of $\frac{1}{500}$ of an inch in diameter with black varnish, and then found it impossible to transmit any rays of even the slightest obliquity through half an inch of such a rod.

From these facts he thinks it may be concluded that it is probable that the highly refractive structures may be regarded in the light of luminous points, which serve as stimuli in exciting the recipient protoplasm in which their ends are imbedded.

The focus of the facet when this is lenticular, in all the insects examined, is situated considerably deeper than the outer end of the rhabdion and below the surface of the rod cells in the microrhabdic eye, so that even for objects as close as $\frac{1}{10}$ of an inch to the cornea, we have to deal with convergent rays, and not with a focal point. This indicates some mode of nerve stimulation other than the union of homocentric pencils, in a point beneath the compound cornea in relation with the recipient elements. Considering the small size of the parts, it is quite possible that we must look to the phenomena of interference for the explanation; at least, they must play an important part in the phenomenon.

Whatever may be the manner in which vision is accomplished, the size of the corneal facets and the general curvature of the cornea render the theory of J. Müller highly probable. It is true that Claparède has expressed the reverse opinion, but he has done so on insufficient data. According to his calculation, a bee should be unable to distinguish objects of less than eight inches in diameter at a distance of twenty feet from it. This calculation is based on the idea that the acuity of vision in this insect is the same in all parts of the field of vision, and that the general surface of the common cornea is approximately a segment of a sphere. This is not the case, for the angles subtended by the adjacent facets in the centre of the cornea, which is considerably flattened, is not more than half a degree at the most; so that on J. Müller's theory, supposing each facet to give rise to only a single luminous impression, the bee should be able to distinguish objects of about two inches in diameter at a distance of twenty feet, an acuity of vision quite equal to account for all the phenomena of vision in bees.

The curvature of the cornea of a number of insects was measured, with a view to determining the angles made by the lines of vision drawn from the centre of adjacent facets. This is done in the following manner:—A magnified image of the cornea is thrown on a sheet of white paper, by means of a microscope and camera lucida, and the curve of its profile drawn; in this way the principal meridians were found. These curves approach more or less closely to an epicycloid.

It is easy with such curves and the size of the corneal facets to determine the angles made by adjacent facets. The angles vary inversely as the radius of curvature, and, therefore, the acuity of vision varies directly as the radius of curvature when the diameter of the facets remains the same, and inversely as the diameter of the facets when these vary in size. In many insects, as *Tabanus*, the peripheral facets of the cornea are twice or three times the diameter of those in the centre, and the radius of curvature is very short at the extreme periphery.

In most insects the acuity of vision determined in this manner diminishes very rapidly at the periphery of the field. In the centre of the field it enables them to perceive, as distinct, objects which subtend one degree. In *Æschna grandis* the sharpness of vision is much greater, as the adjacent facets make an angle of only eight minutes with each other. This was the least angle measured in any insect; but there is no doubt, from the nature of the curve forming the meridians of the eye in the great dragon-flies, that a small part of the centre of the field has a much greater acuity of vision than this; in the wasp the angle subtended by the smallest visual perceptions is twice as great as in *Æschna;* and in the bee it is half a degree.

The size of the corneal facets varies in different insects from $\frac{1}{2000}$ to $\frac{1}{750}$ of an inch in diameter. Their size, except in a few insects, is dependent on the size of the insect, the largest insects having the largest, and the smallest the smallest corneal facets. From this it follows that the vision of large insects is more perfect than that of small ones, except where the curvature of the cornea is very flat. This corresponds with the manner in which the insects fly, the small Diptera flying round in small circles, whilst the larger species take long flights when disturbed or in search of food. The experiments of Müller and others have shown that the direction and length of flight of insects depend largely on their visual powers.*

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* 'Proc. Roy. Soc.,' vol. xxvii. p. 261.

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Krukenberg: Micrography of the Vitreous Basaltic Rocks of the Sandwich Islands.

Periodicals:—

QUARTERLY JOURNAL OF MICROSCOPICAL SCIENCE for July:—

The Embryology of Clepsine. By C. O. Whitman, of Boston. (With 3 plates.)

Observations on the Structure of Cells and Nuclei. By E. Klein, M.D., F.R.S. (With a plate.)

Note by F. M. Balfour on Recent Researches on the Nervous System of the Medusæ.

Proceedings of the Dublin Microscopical Club for January to March.

ANNALS AND MAGAZINE OF NATURAL HISTORY for July:—

Stromatopora as distinguished from *Millepora*. By Dr. Dawson, F.R.S.

On *Teichonia*, a new Family of Calcareous Sponges, with descriptions of two Species. By H. J. Carter, F.R.S., &c. (With a plate.)

The Foraminiferal Nature of *Haliphysema Tumanowiczii* (Bow.) (*Squamulina scopula*, Carter) demonstrated. By W. Saville Kent, F.L.S., F.Z.S., &c. (With 2 plates.)

On *Stromatopora*. By H. J. Carter, F.R.S., &c.

On the Structure of *Haliphysema Tumanowiczii*. By E. Parfitt.

For August:—

Studies on Fossil Sponges. II. Lithistidæ. By Karl Alfred Zittel. (*To be continued.*)

Notes on the Embryology of Sponges. By W. Saville Kent, F.L.S., F.Z.S., &c. (With 2 plates.)

Parasites of the Spongida. By H. J. Carter, F.R.S., &c. (With a woodcut.)

Measurements of the Red Blood-corpuscles of the American Manatee (*Manatus Americanus*) and *Beluga leucas*. By George Gulliver, B.A., Pembroke Coll., Oxon.

Note on *Tethea muricata*, Bowerbank. By H. J. Carter, F.R.S., &c.

HARDWICKE'S SCIENCE-GOSSIP for July:—

The Teeth of the Blow-Fly. By the Rev. L. G. Mills, LL.D., F.R.M.S. (With 2 woodcuts.)—A rare Acarus (*Glyciphagus plumiger*). By A. Michael. (With a woodcut.)—Diatomaceous Material offered by the San Francisco Microscopical Society.—The Quekett Microscopical Club Journal.—On the Wet process of Mounting described in the May number.—Canada Balsam in India.—Plant-crystals.

For August:—

A Chapter on Microscopic Fungi (Perisporiacei). By Greenwood Pim, M.A., F.L.S. (With 7 woodcuts.)—On Tanks for the Breeding and Maintenance of Microscopic Organisms.—How to use the Micrometer. By F. Kitton, Hon. F.R.M.S. (With a woodcut.)—A Good Mounting Medium (Thompson's Cement.) *Volvox globator*.—Microscopy in America.—The Examination of Minute Living Organisms. A Glass-eating Lichen.

NATURE for June 6:—

Letter from F. A. Bedwell: Hints to Workers with the Microscope—(The Cotton Wool "trap").

Note on the "Poly-Microscope."

June 13:—

Resting Spores. By E. Perceval Wright. (An abstract of Dr. Wittrock's paper to the Swedish Academy of Sciences, "On the Spore-Formation of the Mesocarpeæ, and especially of the new Genus Gonatonema.)

June 20:—

Letter from R. E. Dudgeon: Examination of Small Organisms in Water. (The objective enclosed in a metal tube, closed at one end with thin glass.)

June 27:—

Decorative colouring in Fresh-water Fleas. (Summary of the results of Professor Weismann's article on the Daphnoidæ in Siebold and Kölliker's 'Zeitsch. f. wiss. Zool.')

July 4:—

Review of Herr Krukenberg's 'Micrography of the Vitreous Basaltic Rocks of the Sandwich Islands.'

Note on the intended Excursion of the Birmingham Natural History and Microscopical Society to Arran.

July 11:—

Letter from Dr. James Edmunds acknowledging Dr. Barker's priority in the origination of the Immersion Paraboloid.

July 18:—

Professor Schwann's Jubilee at Liége.

Letter from M. M. Hartog on the Lichen Gonidia Question.

The Male of Salpa. (A Summary of Professor Salensky's article in 'Zeitsch. f. wiss. Zool.')

The Structure and Development of Sponges. (A Summary of Professor Keller's article on *Reniera semitubulosa* in 'Zeitsch. f. wiss. Zool.')

A New Camera Lucida (of Dr. J. G. Hofmann). (With a woodcut of the non-microscopic form.)

July 25:—

The Hydroids of the Gulf Stream. Review of Dr. G. J. Allman's Report on the Hydroida collected during the Exploration of the Gulf Stream by L. F. de Pourtalès.

Letter from J. Mayall, jun., on the Immersion Paraboloid.

August 1:—

Note on a "Walking Stick for Naturalists and Tourists" from Dresden (with Compass, Pocket Microscope, Thermometer, Sand Glass, Chloroform or Ether bottle, Measure, Knife for Aquatic Plants, Spade for Botanists, Hammer for Geologists, &c.).

POPULAR SCIENCE REVIEW for July:—

Volvox globator. By Alfred W. Bennett, M.A., B.Sc., F.L.S. (With a plate.)

On the Radiolaria as an Order of the Protozoa. By Surgeon-Major G. C. Wallich, M.D., &c. (With a plate.) (*To be continued.*)

Microscopy.—The New Oil-Immersion Object-glass.

QUARTERLY JOURNAL OF SCIENCE for July:—

Notices of Books.—Review of "Conferences held in connection with the special Loan Collection of Scientific Apparatus, 1876," containing Dr. Royston-Pigott's notice of the Microscopic Researches of Dr. Drysdale and Rev. W. H. Dallinger.

Scientific Notes.—"The Ross Microscope as remodelled by Mr. Wenham."—The Oil-Immersion.—The Journal of the R.M.S.

CROYDON MICROSCOPICAL CLUB, SEVENTH REPORT AND ABSTRACT OF PROCEEDINGS:—

Some Recent Microscopical Researches with respect to Infectious Disease. By C. W. Philpot, M.D.—The Crystals of Lime Salts found in Plants. By W. H. Beety, F.R.M.S.—The Circulation of Sap in Plants. By A. Carpenter, M.D.

Proceedings at Seventh Annual Meeting, Abstract of Proceedings for 1876, &c.

JOURNAL OF THE QUEKETT MICROSCOPICAL CLUB for July (No. 37):—

On *Glyciphagus palmifer*. By A. D. Michael, F.R.M.S. (With a plate.)

A few Remarks on Insect Dissection. By T. Charters White, M.R.C.S., F.R.M.S., &c.

On some Microscopic Tracings of Lissajous' Curves. By R. G. West.

On a new Micrometer. By George J. Burch. (With a plate.)

On a Method of Mounting whole Insects without Pressure for the Binocular Microscope. By Staniforth Green.

On Variation in *Spongilla fluviatilis*. By F. G. Waller. (With a plate.)

Proceedings of Meetings in January–April.

JOURNAL OF THE LINNEAN SOCIETY (BOTANY), Vol. XVII., No. 98 (issued 31st July):—

On the Algæ found during the Arctic Expedition. By G. Dickie, M.D., F.L.S.

Enumeration of the Fungi collected during the Arctic Expedition, 1875–76. By the Rev. M. J. Berkeley, M.A., F.L.S.

AMERICAN JOURNAL OF MICROSCOPY AND POPULAR SCIENCE for June:—

Abdominal Tumour found in Domestic Fowl. By R. W. Couvin, M.D. (With 6 woodcuts.)

Isthmia nervosa: A Study of its Modes of Growth and Reproduction (*conclusion*). By J. D. Cox. (With 2 woodcuts.)

A Discussion of Angular Aperture. By R. Hitchcock. A paper read before the New York Microscopical Society. (With 4 woodcuts.)

A New Cover Adjustment for Microscope Objectives. (With a woodcut.)

How Organisms are found in Clear Water.

Microscopical Field Days.

The National Microscopical Congress.

Correspondence.—H. Mills: Microscopic Organisms in the Niagara River.—Dr. L. Curtis: High Powers with the Binocular.—F. F. Shaw: Cells for Canada Balsam.—A. Y. Moore: First and Second Class Objectives.—Dr. C. H. Stowell: Structure of Blood-corpuscles.—Professor J. Edwards Smith: Choice of Objectives.

Transactions of New York Microscopical Society (19th April, 3rd and 17th May, 7th and 21st June).—State Microscopical Society of Illinois (28th May), and San Francisco Microscopical Society (16th May).

AMERICAN JOURNAL OF SCIENCE AND ARTS for April:—

On the Projection of Microscope Photographs. By J. C. Draper, M.D., LL.D., Professor of Natural History in the College of the City of New York. (With a woodcut.)

On the Influence of Temperature on the Optical Constants of Glass. By C. S. Hastings, of the Johns Hopkins University.

For May:—

The Coralline or Niagara Limestone of the Appalachian System as represented at Nearpass's Cliff, Montague, New Jersey. By Dr. S. T. Barrett, Port Jervis, N.Y.

The AMERICAN NATURALIST for May:—

Hairs and Glandular Hairs of Plants, their Forms and Uses. By Professor W. J. Beal. (With 43 woodcuts.)

Microscopy.—Report of Meeting of the Microscopical Section of the Troy Scientific Association of 1st April, containing Rev. A. B. Hervey's description of a "New Method of Fluid Mounting," and remarks of Dr. Ward on "Bullock's New Self-Centering Turn-table."

For June :—

A Lesson in Comparative Histology. (Histology of the Locust.) By C. S. Minot. (With a plate and 3 woodcuts.)

Microscopy.—A Novel Stand (made for Dr. Blackham by Mr. Tolles).—Soirée of the State Microscopical Society of Illinois on 8th March.—Microscopical Society Elections.—Microscopical Congress.—Ernst Gundlach.—Exchanges.

Proceedings of Troy Scientific Association of 15th April. (Dr. R. H. Ward read a paper on Microscopic Ruling and Engraving.)

For July :—

The smallest Insect known (*Pteratomus Putnamii*). By Hon. J. D. Cox. (With a woodcut.)

Microscopy.—Determination of Rocks by the Microscope. (Paper read at San Francisco Microscopical Society on 16th May, by M. Atwood.)—Oleomargarine.—A rare Sale.—Exchanges.

BULLETIN DE LA SOCIÉTÉ BELGE DE MICROSCOPIE, Vol. IV., No. 8 (issued in June) :—

Note on a Microscope for Mineralogical Researches. By M. Renard. (With a plate.)

Note on the Preparation of the Diatoms. By M. E. Guinard.

Preparation of the Polycystina. By M. Vanden Broeck.

Report on Slides presented by M. R. Lawley.

Reviews of M. J. Fraipont's Researches on the Acinetæ of the Coast of Ostend, M. E. Roze's paper on the Antherozoïds of the Cryptogams, that of himself and M. Cornu on two new generic types for the families of the Saprolignieæ and Peronosporæ (from 'Annales des Sc. Nat.'), one by M. Roze on the Myxomycetæ and their place in the system (from the 'Bulletin de la Société botanique de France'), and of Dr. Van Heurck's translation of Professor Hamilton Smith's Synopsis of the Diatomaceæ.

Proceedings of the Meeting of 31st May.

No. 9 (issued in July) :—

Note on the Development and Classification of the Ferns. By M. von Kruttschnigt.

Report on Preparations presented by Dr. Boecker.

Review of M. J. Fraipont's Researches on the Acinetæ of the Coast of Ostend (*continuation*).

Proceedings of the Meeting of the 27th June.

JOURNAL DE MICROGRAPHIE for June :—

The Rouen School of "Commercial Microscopy."

The Lymphatic Hearts (*continuation*). By Professor Ranvier.

Observations on the Termination of the Motor Nerves of the Striated Muscles of the Torpedoes and the Rays (*continuation*). By Professor Ciaccio.

The Microscopes at the Paris Exhibition. By the Editor (Dr. J. Pelletan).

On the Gold Method and the Termination of the Nerves in the Non-striated Muscles. By Professor Ranvier. (From 'Comptes Rendus.')

Cryptogamic Botany. Syllabus of Professor L. Marchand's Course at the Pharmaceutical School of Paris.

A New Field for the Microscopist (translation of Mr. W. S. Kent's paper in 'Popular Science Review' for April).

On the Measurement of the Dihedral Angles of Microscopic Crystals. By E. Bertrand. (From 'Comptes Rendus.')

Mr. Bolton's Living Specimens for the Microscope. By the Editor.

New Model of Microscope by Mr. R. B. Tolles, of Boston. By G. E. Blackham.

Pumphrey's Autographic Press.

The "Transporter" of Professor Monnier.

Correspondence.—T. Bolton.

For July :—

The Lymphatic Hearts (*continuation*). By Professor Ranvier.

Observations on the Termination of the Motor Nerves of the Striated Muscles of the Torpedoes and the Rays (*continuation*). By Professor Ciaccio.

Preliminary Note on the Development of the Blood and the Vessels. By Drs. V. Brigidi and Al. Tafani.

Microscopy at the Universal Exhibition of Paris. By the Editor (Dr. J. Pelletan).

Note on the Application of Picrocarminate of Ammonia to the Anatomical Study of the Helminthia. By Dr. G. Duchamp.

Cryptogamic Botany. Syllabus of Professor L. Marchand's Course at the School of Pharmacy of Paris.

On the "Gum Disease" of the Lemon Trees (*Fusisporium Limoni*). By C. Briosi.

Abstract of Dr. A. Guillaud's Researches on the Comparative Anatomy and Development of the Tissues of the Stem in the Monocotyledons. By E. Dubreuil.

The Application of the Microscope to the Study of Mineralogy. By Em. Bertrand.

A New Field for the Microscopist (continuation of the translation of Mr. Kent's paper). (With a plate.)

&c. &c. &c.

ANNALES DES SCIENCES NATURELLES (ZOOLOGY), Sixth Series, Vol. VII., No. 1 (issued in March) :—

Researches on the Optic Rod in the Crustacea and the Worms (*continuation*). By M. J. Chatin. (With 3 plates.)

Observations on *Notommata Werneckii*, and on its Parasitism in the Tubes of the *Vaucheriæ*. By M. Balbiani. (With a plate.)

ANNALES DES SCIENCES NATURELLES (BOTANY), Sixth Series, Vol. V. Nos. 4 and 5 (issued in June) :—

On the Ovule. By M. E. Warming. (With 7 plates.)

The Causes of the Abnormal Forms of the Plants which grow in the dark. By N. W. P. Rauwenhoff. (With 2 plates.)

SIEBOLD AND KÖLLIKER'S ZEITSCHRIFT FÜR WISSENSCHAFTLICHE ZOOLOGIE, Vol. XXX., Supplement, 3rd part (issued 28th May) :—

On the First Embryonal Development in *Tendra zostericola*. By W. Repiachoff. (With a plate.)

Contributions to the Knowledge of the Protozoa. By A. Schneider. (With a plate.)

On the Forms and Signification of the Organic Muscle-cells. By W. Flemming. (With a plate.)

Observations on the Anatomy of *Limnadia Hermanni* (Brongn.). By Fr. Spangenburg.

On the Structural Continuity of the Brain in the different Orders of Insects. By J. H. L. Flögel. (With 2 plates.)

JOURNAL

OF THE

ROYAL MICROSCOPICAL SOCIETY.

NOVEMBER, 1878.

I.—*On the Fossils called "Granicones"; being a Contribution to the Histology of the Exo-skeleton in "Reptilia."*

By Professor Owen, C.B., F.R.S., F.R.M.S., &c.

(*Read before the* Royal Microscopical Society, *October* 9, 1878.)

Plates XII. and XIII.

The British Museum lately acquired, by purchase, the collection of fossils made by Samuel H. Beckles, Esq., F.R.S , F.G.S., in the "Feather-Bed Stratum," Middle Purbecks, Dorsetshire.

The mammalian remains had previously been submitted to me by their discoverer for determination and description, and they form the subject of the preliminary chapter of my work on 'Marsupial Fossils.'*

In working out the residuary slabs and pieces of matrix from the above-named formation, some interesting additional evidences of the *Reptilia* of the period were brought to light, and among them the bodies figured in Plate XII., Figs. 1–5, natural size, to

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EXPLANATION OF THE PLATES.

Plate XII.

Figs. 1–3.—Granicones of the larger size.
Fig. 4.—A granicone showing an oblique base.
„ 5.— „ with a beaded border at the base, the apex broken off.
„ 6.—Transverse section of a granicone; nat. size in outline, and magnified 2 diameters.
„ 7.—The portion indicated by the circular line in Fig. 6; magnified about 8 diameters.
„ 8.—Portion of jaw and teeth *in situ, Nuthetes destructor*; nat. size.
„ 9.—Detached teeth of the same species; nat. size.
„ 10.—Portion of section of a granicone; magnified about 333 diameters.

Plate XIII.

Fig. 1.—Outline of a scute of *Theriosuchus pusillus*; nat. size.
„ 2.—Two scutes of do.; magnified 2 diameters.
„ 3.—A section of scute; magnified about 33 diameters.
„ 4.—A section of scute; magnified about 333 diameters.

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* 'Researches on the Fossil Remains of the Extinct Mammals of Australia, with a Notice of the Extinct Marsupials of England,' 4to, 1877, vol. i. pp. 21–104.

which, provisionally and for the purpose of registration, I assigned the name "granicone," suggested by their shape and surface.

All were conical, with a comparatively smooth base (Fig. 4, *b*); the rest of the outer surface was of a denser and smoother texture, but beset with granules of about a millimetre in diameter, more or less. The largest of these "granicones" are the subjects of Figs. 1, 2, and 3; the smallest were rather more than half that size. The variations of shape were in the degrees of obliquity of the base, the extreme of deviation from a right angle to the cone's axis being shown in Fig. 4. The margin of the base was formed, in some, by a single series of granules, like a circle of beads, as in Fig. 5, from which the apex of the cone was broken away.

Conceiving these bodies to be dermal bones or appendages, their conical shape suggested first a comparison with those of certain rays and sharks, but the osteo-dentine and ganoine shown in microscopical sections, and the disposition of the canaliculi* ramifying from the central cavity, at once distinguish the structure of such piscine dermal cones and spines from that shown in similar sections of the granicones.

I may add, also, that the geological deposit containing these fossils is a fresh-water one, and that no evidence of *Sturionidæ* or other fishes with ganoid plates, habitually or temporarily frequenting rivers or lakes, has been met with in the portions of matrix showing the fossil bodies in question.

Bones and teeth of various *Reptilia* are, however, abundant. They have afforded materials for a monograph on certain new and small forms of *Crocodilia;* but the associated osseous scutes, or dermal bones referable to this order of *Reptilia* are unmistakable. On the hypothesis of the "granicones" being similar parts of some member of the same cold-blooded air-breathing class, there were several extinct genera of *Lacertilia*, represented by associated fossil bones and teeth, to one of which, it seemed probable, the bodies in question might have belonged.

I may remark that in certain *Dinosaurs* (*Hylæosaurus*, *Scelidosaurus*, e. g.), some of the dermal scutes with flat or with oblique bases of attachment, rise thence in a pyramidal form. But these much exceed in size the largest of the "granicones." There was no trace, moreover, of any species of either of the above extinct Wealden or Liassic genera in the Becklesian Collection.

The associated Lacertian fossils which, by their number and

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[*] "Tubes de dentine" of Prof. Hannover, who, in his excellent memoir 'Sur la Structure et le Developpement des Écailles et des Épines chez les Poissons cartilagineux,' thus describes their course in the dermal scales along the mid-line of the back of the sting-ray (*Trygon*):—"Du réseau sortent les tubes de dentine, qui rayonnent de tous les côtés dans la partie libre et pyramidale de l'écaille," p. 3. See also Quekett, 'Histological Catalogue, Mus. Coll. of Surgeons,' 4to, vol. ii. 1855, pp. 86, 87.

size, best agreed with the granicones, on the hypothesis of these being "dermal bones" of such, were the teeth (Figs. 9 and 10), and bones (Fig. 8) of the extinct species which I have called *Nuthetes destructor.*[*]

Amongst the existing forms of Lizards the dermal armour of the Australian species *Moloch horridus* is that which most resembles the bodies in question, except that the surface of the cone is smooth and corneous, the hard, horny cone being hollow, and sheathed upon a conical process of dense dermal tissue. I have not detected a trace of ossification in this tissue of the existing lizard.

The resemblance, however, of its texture, as exposed by thin slices, with a section of the bony body of a "granicone," such as is shown under a moderately magnified power in Fig. 7, Plate XII., was suggestively close. Decussating bands of fibrous tissue, closely matted, in the body of the dermal cone of *Moloch*, wanted only the addition of osseous matter to repeat the texture shown in Fig. 7.

I have already referred to the characteristic microscopical structures of the conical scutes and spines of the Thornback-rays, Trygons, and other Placoids of Agassiz. In Quekett's excellent and useful work [†] the osseous tissue of the endo-skeleton only of the class *Reptilia* is described and illustrated. The scutes, spines, and scales of the *Lacertilia*, indeed, so far as I have yet observed, with the exception of the long spines supporting the crest of the Basilisk, are horny, and supported by dense though unossified corium. But in the existing *Crocodilia*, especially in the dorsal region, the larger scutes have an osseous basis, coated by a thin horny or epithelial layer.

The application of the histological characters of the fossil dermal scutes associated in the same slab of matrix with the bones and teeth of the small Purbeck Crocodile (*Theriosuchus pusillus*, Ow.) induced me to resume a long-abandoned line of research, and to submit the results to the Society, in the establishment of which I had the pleasure to co-operate at a period when a great proportion of my anatomical researches was aided by the microscope.

In Plate XIII. a dorsal scute of the Crocodile in question is outlined of the natural size in Fig. 1, and the mode of overlapping is indicated by the dotted line in a contiguous scute, twice the natural size, in Fig. 2. The scutes in the present extinct genus have the same peg-and-groove joints as in the larger Purbeck genus *Goniopholis*, but the dentition of this crocodile is generically distinct from that of the diminutive *Theriosuchus*.

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[*] 'Monograph on the Fossil Lacertian Reptiles of the Purbeck Limestones,' in the volume of the Palæontographical Society, issued 1860, 4to, p. 31; and 'Quarterly Journal of the Geological Society,' 1854, p. 120.

[†] *Op. cit.*, pp. 108–134, plates viii. and ix.

The section of the scute (Fig. 3) exposes the large and irregular sinuses from which the Haversian canals are continued, and the numerous bone-cells or "lacunæ." The structure of the latter, as seen in transverse sections, is shown by the higher magnifying power, $\frac{500}{1}$, in Fig. 4. They are notable for the great number of their canaliculi, and their correspondence with those of the osseous tissue of the femur of the Crocodile* is close. The dermal bone is chiefly distinguished by the greater proportion of the unossified part, indicated by the wider sinuses which are filled in the fossil by the opaque matrix.

A section of a granicone (Plate XII., Fig. 10) showing some of the "lacunæ" in transverse section; others longitudinally divided, differs from the crocodilian scute in the fewer sinuses and more numerous Haversian canals, the direction of which is followed by the long diameters of the lacunæ.

The section of the osseous tissue of the femur of a Monitor Lizard, figured by Quekett (plate ix., fig. 30), shows the same diversity of the "lay" of the lacunæ, some being divided transversely, others obliquely or longitudinally, as in the section of the granicone herewith submitted to the Society, and part of which is figured in Plate XII., Fig 10.

In both dimensions, in size, shape, and number of canaliculi, the lacunæ of the granicone most nearly resemble those of the Lacertians, as described and figured in Quekett's 'Histological Catalogue' (vol. ii. p. 122, plate ix., figs. 17, 30, 32). I therefore conclude that the granicones are dermal scutes, that they are Lacertian, and, as far as contiguity and association indicate, have formed part of the external armour of the large extinct Purbeck Lacertian, *Nuthetes destructor.*

If my determination prove correct, this species must have presented the same formidable and singular character of dermal defence as does the recent Australian lizard already alluded to, and which has thence received the name of *Moloch horridus.* The chief distinction is the ossification of the horn-like scutes in the old secondary genus, whereby they have come down to us in the fossil state.

It is not without interest to note that the mammalian fossils associated and contemporaneous with the *Nuthetes* are marsupial, and that wherever a family or generic relationship can be determined between them and still existing or recently extinct species, such species, like *Moloch horridus,* are Australian.

* Quekett, *op. cit.*, pl. ix. fig. 7.

II.—*On some New Genera and Species of Diatomaceæ.*

By M. P. Petit. Translated by F. Kitton, Hon. F.R.M.S., by the kind permission of the Author.

(*Taken as read before the* Royal Microscopical Society, *June* 5, 1878.)

Plates XIV. and XV.

In the 'Fond de la Mer' M. P. Petit has given a list of Diatomaceæ collected by the expedition sent by the French Government to Campbell Island,* in the year 1874, for the purpose of observing the transit of Venus. Dr. Filhol, one of the gentlemen appointed by the Government, after leaving the expedition, travelled alone in New Zealand, and the forms obtained by him are also included in M. Petit's list.

DESCRIPTION OF THE PLATES.

Plate XIV.

Fig. 1.—*Cocconeis notata* (P. Petit), *n. sp.*
„ 2.— „ *australis* (P. Petit), *n. sp.;* *a*, frustule; *b*, inferior valve; *c*, superior do.
„ 3.—*Cocconeis Wrightii* (O'M.), *new form.*
„ 4.— „ *Crux* (Ehr.).
„ 5.—*Campyloneis Grevillii* (Grun.); *a*, frustule; *b*, one of the plates of the inferior valve; *c*, second plate of do.; *d*, superior valve.
„ 6.—*Rhaphoneis fasciolata* (Greg.), *n. var.*
„ 7.—*Hyalodiscus maximus* (P. Petit), *n. sp.* × 200 diameters; *a*, valve; *b*, f. v. of do.
„ 8.—*Amphora cristata* (P. Petit), *n. sp.*
„ 9.— „ *aspera* (P. Petit), *n. sp.*
„ 10.—*Epithemia* (?) *monilifera* (P. Petit), *n. sp.*
„ 11.—*Navicula decussata?* (Ehr.), (Kg.).
„ 12.— „ *Rhombus* (P. Petit), *n. sp.*
„ 13.— „ *Hennedyi* (Wm. Sm.), *n. var.*
„ 14.— „ *Smithii* (Breb.), *β minor* (P. Petit).
„ 15.— „ *biseriata* (P. Petit), *n. sp.*

Plate XV.

„ 16.—*Stauroneis robusta* (P. Petit), *n. sp.*; *a*, valve; *b*, frustule.
„ 17.—*Amphiprora rugosa* (P. Petit), *n. sp.*
„ 18.—*Surirella Filholii* (P. Petit), *n. sp.*
„ 19.—*Trachysphenia australis* (P. Petit), *n. gen. and sp.*
„ 20.—*Grammatophora marina* (Kg.), *n. var.*
„ 21.— „ *longissima* (P. Petit), *n. sp.*
„ 22.—*Rhabdonema hamuliferum* (Kitton), *n. sp.*
„ 23.—*Navicula Campbellii* (P. Petit), *n. sp.*
„ 24.— „ *quœrnerensis* (Grun.), var. *dilatata* (P. Petit).
„ 25.—*Auliscus stelliger* (P. Petit), *n. sp.*

All the figures, excepting Fig. 7, are × 600 diameters.

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* Campbell Island is in the South Pacific; lat. 52° 33′ S., long. 169° 8′ E. (London). It is of volcanic origin, 36 miles in circumference, and 1500 feet above the sea-level.

COCCONEIS.

1. *C. notata* (P. Petit). Valves ovate, median line sigmoid, central nodule dilated into a smooth band (pseudo-stauros) reaching the margin and terminated at one margin by a circular hyaline enlargement. Striæ transverse, very close, subradiant, and finely punctate, reaching median line. Length 26 μ 4, breadth 13 μ 6.*

Lyell's Bay. Pl. XIV., Fig. 1.

2. *C. australis* (P. Petit). Valves dissimilar, small suborbicular, the inferior (Fig. 2*b*) having a sigmoid line. Striæ longitudinal, close. The superior valve (Fig. 2*c*) smooth, but furnished with short distant marginal costæ (closely resembling the canaliculi of the Surirellæ). Length 26 μ 4, breadth 24 μ 2.

Lyell's Bay. Pl. XIV., Fig. 2.

3. *Raphoneis fasciolata*, var. australis (P. Petit). This form shows characters differing from the type. The rows of granules increase in length as they approach the centre, producing a very marked contraction in the smooth space occupying the centre of the valve. This variety is very variable in shape and size, its length varying between 28 μ 6 and 55 μ.

Lyell's Bay, where it is very abundant, but it does not occur in other localities. Pl. XIV., Fig. 6.

HYALODISCUS, Ehr.

(Cleve *emend.: Diatoms from the Arctic Sea*, p. 4.)

Note on the Genus.—M. Cleve has already verified the affinities of all the discoid species with a central fracture or umbilicus. These he has correctly united in a single genus Hyalodiscus of Ehrenberg. We have moreover remarked, that in all the species placed in Podosira the zone is curved in an opposite direction to that which exists in *P. Montagnei.* In examining *H. hormoides* (*P. hormoides*, Ktz.) living, we have seen that the endochrome has nothing in common with that of the true Podosiræ; it is granular, as it is in the Melosiræ to which it belongs. The endochrome in *H. hormoides* forms a single plasmatic layer with four lobes, and always resembling in disposition the endochrome of Achnanthidium; it is only in contact with one side. These characters clearly indicate that *H. hormoides* ought to be classed with the Achnantheæ if we follow the system of classification proposed in our list of diatoms,† and it is probable other species of the genus exhibit the same peculiarities if we had the opportunity of studying them.

4. *H. maximus* ‡ (P. Petit). Valves discoid, very large, central

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* 1 μ = ·0001 of a metre, ·001 of an English inch = 25 μ 339.

† See 'M. M. J.,' vol. xviii. p. 10.

‡ Eulenstein has previously published a species which he has named *maximus.* See Habirshaw's 'Catalogue of the Diatomaceæ.'

umbilicus occupying one-third of the entire diameter; the valves appear striated under a low power, but when more highly magnified the puncta are seen to have a quincuncial arrangement; a ring of crossed striæ surrounds the margin; zone narrow and curved. Diameter 70 μ 4 to 130 μ, umbilicus about 25 μ to 50 μ.

Campbell Island. Pl. XIV., Fig. 7.

This species is very variable in size; the umbilicus is dark in colour; with a low magnification the striæ appear radiant, but under high-power objectives the puncta are found to be arranged in quincunxes. This arrangement, and the absence of dark robust striæ starting from the umbilicus, distinguish this species from *H. radiatus* (*Pyxidicula radiata*, O'Meara*).

[M. Petit is correct in placing *Podosira hormoides* and *P. maculata* in the genus Hyalodiscus. Herr Cleve and M. Petit are, however, incorrect in making a distinct species of *H. maculatus* (*P. maculata*, Wm. Smith); it is identical with *H. stelliger*, Bailey, of which I have seen authentic examples (and perhaps with *Craspedodiscus stella*, Ehr.). Professor H. L. Smith also confirms this.†

It appears very doubtful to me whether *H. subtilis* of Bailey is the same as *H. Franklinii*: his figure ‡ represents a form with a small umbilicus and two sets of curvilinear striæ intersecting each other like the engine-turning on the back of a watch.

H. Franklinii (probably the same as *H. californicus*) has very fine radiating striæ, certainly invisible with the objectives used by Bailey twenty years ago.

H. subtilis is a much smaller form than the preceding: my specimens (from the English Channel and the Sandwich Islands) do not exceed in size the smallest valves of *H. Franklinii*, and the diameter of the umbilicus is not more than one-half the diameter of that in *H. Franklinii*.

Discoplea umbilicata, Ehr., is perhaps the same as *H. hormoides*. M. Petit refers *Coscinodiscus punctulatus*, Greg., to *H. stelliger*. With this I do not concur; Gregory would, I imagine, have been well acquainted with *Podosira maculata* of the 'Synopsis'; moreover, his figures and description § do not agree with *H. stelliger*.

In one of the 'Tuscarora' soundings I have occasionally seen a disk only differing from *Actinocyclus interpunctatus* (Brightwell) in having a very small umbilicus. It also occurs in a gathering from the island of St. Paul, a slide of which was kindly sent me by M. Petit.

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* 'Jour. of Linn. Soc.,' vol. xv., "Diatom. Kerguel.," p. 56, pl. i. fig. 9.

† 'American Journal of Microscopy,' vol. ii. p. 149.

‡ 'Smithsonian Contributions,' vii. p. 10, f. 12, 1853.

§ 'T. M. S.,' vol. v. pl. i. fig. 48; 'Clyde Diatoms,' p. 28, pl. ii. fig. 46.

H. lævis, Ehr., and *H. patagonicus*, Ehr., are only known to me through the very imperfect figures in the 'Mikrogeologie.'

Apparently allied to *H. maximus* and *Pyxidicula radiata* is Weise's *Craspedodiscus radiatus*.* His figure represents a disk with a large umbilicus on which a number of distinct granules are concentrically disposed; the remainder of the disk has very fine radiating striæ; the diameter of disk (× 300) according to his figure is exactly one inch, diameter of umbilicus $\frac{6}{10}$. If these forms be distinct, their specific names must be changed, as they all undoubtedly belong to one genus.—F. K.]

Amphora, Ehr.

5. *A. Schmidtii* (P. Petit). 'A. S. Atlas,' pl. xxviii. fig. 51, without name or diagnosis. Valves cymbiform, slightly turgid at the centre of the ventral margin (*du côté le moins courbe*); extremities rounded; median line faintly curved. Striæ transverse, on the dorsal side (*du côté le plus courbe*) of the median line short, distinct, submarginal, slightly radiant, not reaching the median line by a length equal to the diameter of the valve; striæ on ventral side very short, close to but not touching the median line, interrupted opposite the centre by a blank space. Median line subcentral. Length 88 μ, breadth 15 μ 4.

Foveaux Strait.†

6. *A. cristata* (P. Petit). Valves cymbiform, with capitate extremities suddenly contracted below the apices; ventral margin abruptly inflated at the centre, median line very close to this margin. The dorsal margin has a large crenated ridge, the crenations of which gradually decrease in breadth as they approach the apices. Striæ distinct, parallel on the valve radiating on the ridge: about 25 in 25 μ. Average length 77 μ, greatest breadth with the ridge 19 μ.

Very abundant in Foveaux Strait. Pl. XIV., Fig. 8.

This beautiful species approaches very near to *A. sinuata* in outline, but differs in the valve being distinctly divided into two parts, the valve proper, and the so-called ridge; it is also larger.

7. *A. aspera* (P. Petit). Valves cymbiform, with extremities attenuated, sub-capitate, rounded, and slightly recurved; median line for the greater part of its length and the central nodule obscured by the ventral margin. Striæ punctate, radiant, resembling those of *Stauroneis aspera*, reaching the median line on the dorsal side. Length 57 μ 2, breadth 13 μ 2.

Foveaux Strait. Pl. XIV., Fig. 9.

This species resembles *A. rhombica*,‡ but differs in size, and the extremities are recurved.

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* 'Bull. Imp. Acad. St. Petersburg,' vol. vi. p. 311, pl. ii. fig. x.

† Foveaux Strait, New Zealand; lat. 46° 40′ S., long. 168° 10′ E.

‡ Kitton, 'Schmidt's Atlas,' pl. 40, fig. 39.

Epithemia, Bréb.

8. *E.? monilifera* (P. Petit). Valves arched, covered with large moniliform granules, 2 μ 2 in diameter, irregularly disposed, often with stout transverse radiant costæ. [The few specimens I have seen never had more than three.—F. K.] Length 72 μ 6 to 188 μ 4, breadth 15 μ 4.

Foveaux Strait. Pl. XIV., Fig. 10.

This species very much resembles Schmidt's *Amphora monilifera*,* which he doubtfully refers to *A. monilifera* of Gregory;† but as neither median line nor central nodule is present, it must be placed among the Epithemias. The transverse costæ present on some individuals confirm this view. On the other hand, the characters are not well marked, and the connecting zone is indistinct, making us doubt the bivalvular nature of the siliceous envelope. We ought, perhaps, to consider this organism as much a Polycystin as a diatom. [The resemblance to *A. monilifera* does not seem to me very apparent; it more nearly approaches Grunow's *Euodia Frauenfeldii*.—F. K.]

Navicula, Ehr.

9. *N. quærnerensis* (Grun.), var. *dilatata*, P. Petit. This variety is distinguished from the type by its larger size and scarcely produced apices; the striæ are subradiant and very delicate; this character, together with the general aspect of the valve, will not permit us to consider this form as anything else than a variety of Grunow's species. Length 33 μ, breadth 37 μ 6. [Query, should not these figures be transposed?—F. K.] Striæ, 40 in 25 μ.

Campbell Island. Pl. XV., Fig. 24.

10. *N. Campbellii* (P. Petit). Valves lanceolate, with concave margins; extremities cuneiform; apices rounded; median line straight; central nodule indistinct, surrounded by a circular blank space. Striæ distinct, slightly radiant at the centre, parallel towards the extremities, reaching median line, excepting at the centre; no longitudinal striæ. Length 84 μ 4, breadth 22 μ; 18 to 20 striæ in 25 μ.

Campbell Island. Pl. XV., Fig. 23.

This species is closely allied by its form to *N. constricta*, Grunow,‡ but differs from that species in the striæ reaching the median line.

11. *N. biseriata* (P. Petit). Valves lanceolate, extremities attenuated, apices rounded, median line not reaching the ends of the valve, central and terminal nodules distinct. Striæ radiant interrupted, absent on one side of the central nodule resembling a

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* 'Atlas,' pl. 26, fig. 32.

† 'Diatoms of the Clyde.'

‡ 'Verh.,' 1860, p. 355, fig. 18.

demi-stauros. Frustule constricted at the centre, ends truncate, connecting zone smooth. Length 55 to 74 μ, breadth 17 μ 6.

Foveaux Strait. Pl. XIV., Fig. 15.

This is a remarkable form; in the s. v. it appears to be allied to *N. Richardsoniana*,* from which it differs by the terminal nodules being placed a little below the apices, and by the blank space on one side of the central nodule. [In this respect resembling Pfitzer's genus Anomæoneis.—F. K.]

12. *N. rhombus* (P. Petit). Valves conspicuously rhomboid, apices acuminate and slightly produced, median line straight, nodules very small, striæ decussating and very close. Length 36 μ 6, breadth 24 μ 2; about 35 striæ in 25 μ.

Foveaux Strait. Pl. XIV., Fig. 12.

This little species is remarkable for its rhomboid form and crossed striæ, which under a high power form lozenges arranged in quincunxes. It is very closely allied to the species described and figured by Lewis † as *N. placentula*, Ehr. [This is not *N. placentula*, but *N. rostellum*, W. S., 'Sy. Brit. Diat.,' vol. ii. p. 93 = *N. apiculata*, Greg., 'Quart. Jour. Mic. Sci.,' vol. iv. p. 4, pl. i. fig. 13. I have seen authentic specimens of this form; it is not uncommon in fresh-water gatherings from Morven, Aberdeenshire, communicated by my friend, the Rev. G. Davidson of Logie Coldstone.—F. K.]

STAURONEIS, Ehr.

13. *S. robusta* (P. Petit). Valves elliptical, suddenly acuminate towards the ends; median line straight; central nodule large, terminal nodules small and placed a little below the apices; stauros dilated towards the margin, but which it does not reach; striæ interrupted by marginal blank spaces; margin annular, striated; frustule strongly contracted at the centre, and largely rounded at the summits; connecting zone smooth. Length 90 to 101 μ, breadth 28 μ. Striæ, 18 in 25 μ.

Foveaux Strait. Pl. XV., Fig. 16.

This species is distinguished from all others by its suddenly acuminated apices, the position of the terminal nodules, its annular margin, the interruption of the striæ, the contraction of the frustules at the centre, and their rounded apices.

[This form undoubtedly belongs to the group of which *Navicula aspera* (*S. pulchella*, W. S.) is the type. The forms have no true stauros, but only a median blank space, which is sometimes dilated, and sometimes circular.—F. K.]

AMPHIPRORA, Ehr.

14. *A. rugosa* (P. Petit). Valves in f. v. narrow, contracted at the centre; apices terminating in curved points; striæ represented by

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* O'Meara, 'Irish Diat.,' p. 339, pl. 32, fig. xxxiii.

† 'U. S. Diatoms,' part iii. p. 8, pl. ii. fig. 7.

puncta irregularly disposed, and giving the valves a rugose appearance. Length 132 μ.

Campbell Island (rare). Pl. XV., Fig. 17.

[This form belongs to my genus Perrya.—F. K.]

SURIRELLA, Ehr.

15. *S. Filholii* (P. Petit). Valves elliptical; margin contract; extremities largely rounded; costæ dilated towards the margin, not reaching to the centre; each of these has two or three firmly punctate striæ of the same length as itself. Midway between the summits and the centre are two short parallel punctate lines (*vers le centre se trouvent deux lignes punctuées et atrophiées*). Length 108 to 126 μ, breadth 42 to 54 μ.

Foveaux Strait. Pl. XV., Fig. 18.

This beautiful species (dedicated to M. le Dr. H. Filhol) is allied to *S. arabica*, Grun., in Schmidt's 'Atlas,' pl. xx. fig. 5; but it does not possess the uncontracted second margin of that species; its costæ are also more distant. Its place is between *S. fastuosa* and *S. arabica.*

TRACHYSPHENIA,* P. Petit.

This genus by its cuneiform valves establishes its connection between the Fragilarias and Meridion. The frustules, as seen in f. v., are quadrangular. The cuneiform valves are covered with puncta disposed in vertical and horizontal lines at right angles to each other. The costæ of Plagiogramma do not exist here.

16. *T. australis*, P. Petit. Characters same as genus. Length 35 to 52 μ, breadth 8 to 11 μ.

Lyell's Bay; Campbell Island. Pl. XV., Fig. 19.

[The valves can scarcely be called cuneiform; they are elliptic-lanceolate, and the ends are usually symmetrical. O'Meara refers a similar form to the genus Terebraria, of Greville (*T. Kerguelensis*, 'Linn. Soc. Jour.,' vol. xx. p. 56, pl. i. fig. 4). It is perhaps identical with *Fragilaria pinnatula*, Ehr., 'Mik.,' pl. xxxv. A, xxii. fig. 8. *T. australis* differs from *T. Kerguelensis* by its larger granules and the blank spaces at the apices.—F. K.]

GRAMMATOPHORA.

17. *G. longissima* (P. Petit). Frustular view narrow; undulations of the villi nearly reaching the centre; number of undulations 25. Length 114 μ, breadth 8 μ 8.

Lyell's Bay (rare). Pl. XV., Fig. 21.

This curious species is distinguished from *G. serpentina* by the narrowness of the valves, and the extremities of the undulation

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* Τραχύς, rough; and Σφήν, a wedge.

being straight as in *G. marina*. I have been unable to obtain a s. v. of the diatom. I, however, believe them to be arcuate.

RHABDONEMA.

18. *R. hamuliferum* (F. Kitton). Valves lanceolate, undulate, with transverse punctate striæ, ends rounded smooth, diaphragms * striate their whole length, having in their centre a circular ring, and towards the extremities two others much smaller and elliptical. Seen in f. v. the frustules appear composed of a variable number of diaphragms (annuli) placed between the two valves, and separated the one from the other by lines in the form of hooks; each of the diaphragms is striated on the edge. Length 33 to 78 μ, breadth 11 to 15 μ.

On corallines, Lyell's Bay. Pl. XV., Fig. 22.

This form is distinguishable from all other species of Rhabdonema by the undulations of the margin of the valves, and by the lines separating the diaphragms being bent in the form of hooks. Mr. Kitton recognized it as new, and named it *hamuliferum*.

AULISCUS, Ehr.

19. *A. stelliger* (P. Petit). Valves circular, with four processes, two of which are very small. The valve is divided into three concentric parts, the innermost has five stellate rays, the intermediate portion has the rays irregularly disposed, the external circle has a row of puncta on the inner margin corresponding with the rays of the intermediate part; in this outer ring are situated the four processes, between which are irregular rays. Diameter 35 μ 2.

Campbell Island (rare). Pl. XV., Fig. 25.

This species is distinguished from all other Aulisci, recent or fossil, by the peculiarity of the disk and by the presence of the interrupted rays.

The following genera and species of other authors are figured by M. Petit:—

1. *Cocconeis Wrightii* (O'Meara), 'Q. M. J.,' vol. vii. n. ser. p. 246, pl. vii. fig. 6.

Lyell's Bay. Pl. XIV., Fig. 3.

The figure here given represents a very small form, not exceeding 13 μ to 26 μ 4, but the difference from the type form is too little to allow of its being considered a variety; by altering the focus of the objective a dilated cruciform nodule may be detected.

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* The so-called diaphragms as figured by M. Petit are valves; the diaphragms (annuli) in this genus are only striate on the edges. The "hooks" represent the septa as seen in s. v.

2. *C. Crux* (Ehr.), 'Monatsberichten,' p. 265.

Lyell's Bay. Pl. XIV., Fig. 4.

3. *Campyloneis Grevillii* (Wm. Sm.).

Since the creation of the genus by Herr Grunow, he has discovered that *C. Grevillii* consists of two valves; the inferior is composed of two superimposed plates of silica, of which no drawing has previously been given. Fig. *a* represents a complete frustule; Fig. *d*, the superior valve; *b* and *c*, the two plates of silica composing the inferior valve.

4. *Navicula decussata?* Ehr. 'Bericht. Berl. Akad.' p. 364. Length 30 to 39 *μ*, breadth 7 *μ* 7.

Lyell's Bay. Pl. XIV., Fig. 11.

This species with crossed striæ has not been previously figured; I therefore doubtfully refer the present form to this species. Nevertheless all the characters correspond with those given by Ehrenberg.

5. *N. Hennedyi* (Wm. Sm.), var. *β constricta.*

Foveaux Strait. Pl. XIV., Fig. 13.

This form has probably not been figured; it is chiefly remarkable on account of its occurrence with a species essentially elliptical, clearly showing that the contraction of the margins is of no value as a specific distinction.

6. *N. Smithii* (Breb.), var. *β* minor (P. Petit), n. var.

This variety is distinguished by its broadly rounded ends, and its finely punctate striæ. Length 33 *μ*, breadth 19 *μ* 8, costæ 15 to 16 in 15 *μ*.

Lyell's Bay. Pl. XIV., Fig. 14.

7. *Grammatophora marina* (Lyng., n. var. (P. Petit).

This variety differs from the type, by the lines of the diaphragms being more bent.

Foveaux Strait. Pl. XV., Fig. 20.

New Diatoms from Honduras. By Herr GRUNOW.

'Monthly Microscopical Journal,' October 1, 1877.

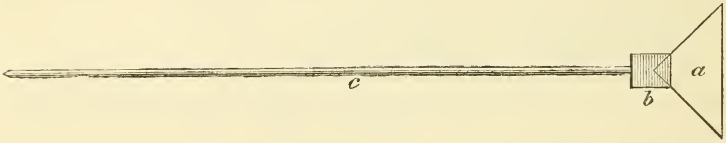
ERRATA.—PL. CXCIII., for 11 *a b c d*, read 10 *a b c d*; for 10 *a b c*, read 11 *a b c*.

III.—*Further Remarks on a "Simple Device" for the Illumination of Balsam-mounted Objects for Examination with Immersion Objectives whose Balsam Angle is* 90° *or upwards.*

By J. J. Woodward, Surgeon and Brevet Lieut.-Col. U.S. Army.

(*Read before the* Royal Microscopical Society, *October* 9, 1878.)

Since the publication of the original paper in the 'Monthly Microscopical Journal' for August, 1877 (p. 61), I have been in the habit of using a similar prism to that there described, without any diaphragm, in the ordinary lamplight illumination of balsam-mounted tests for study with objectives of the kind referred to. The apparatus is so simple, so easily manipulated, and so effective, that a brief description may be of interest.



A right-angled prism of crown glass (*a*), the long side of which is three-quarters of an inch long by half an inch wide, has its right angle truncated as in my "simple device," and cemented to a small base-piece of brass (*b*) which is supported in a stiff steel rod (*c*) three or four inches long, and about the thickness of a knitting needle. The whole apparatus ought not to cost more than three or four shillings.

To use it, I slip the steel rod into the holder of the rod of the dark well usually employed with the Lieberkühn mirrors. This holder fits into the sub-stage of the microscope, and putting a drop of oil of cloves on the upper face of the prism, it is racked up into optical contact with the lower surface of the slide. I then condense the light of a small coal-oil lamp upon the object, through either face of the prism, by a small bull's-eye lens of about three inches focal length. One half of this condensing lens may be covered with black paper, in which case it can readily be so placed that no ray forming a smaller angle with the optical axis than 45° can enter the objective. Excellent results can be obtained, however, without this precaution, if the intention be merely to resolve a given test, without caring to know precisely the angle at which this is done; in this case it is only necessary to place the lamp in such a position that a line drawn from its flame to the face of the objective shall be perpendicular to either short side of the prism, and condense the light in that line. By looking through the other short side of the prism the observer can readily see when the face of the objective is best illuminated.

For the illumination of immersion objectives which do not much exceed 82° balsam angle, I sometimes also use in the same way a prism of 98° angle, and get thus very good results. I have sent one of each of these prisms to Mr. Mayall, with the request that he will exhibit them to those interested.

Prisms of various other angles may be used, and illumination of any desired obliquity thus secured. It may be laid down as a principle that such delicate striæ as those of *Amphipleura pellucida* will be most strikingly separated by any given objective, when the most oblique pencil it can admit without distortion of the image is used. But, practically, I have found as yet no objectives which bear, without distortion of the image, a much greater angle of illumination than can be obtained with the 90° prism, and for objectives of lower balsam angle than 90°, but greater than 82°, the 98° prism answers quite as well as one of more nicely adjusted intermediate angle. Immersion objectives of still lower balsam angle than 82°, which cannot be illuminated even with this prism, may be rejected as unworthy serious consideration at the present day.

The two prisms just described will be found, then, to answer all practical uses with our present objectives, and I think it will probably be cheaper to have two separate prisms than to grind a single one, the two short sides of which should be respectively at angles of 45° and 49° with the optical axis, which would of course answer the same purpose.

In this connection, I may remark that the general recognition, in the United States, of the great angles obtainable for immersion objectives, several years ago suggested the importance of immersion condensers to our instrument-makers. Mr. R. B. Tolles wrote in 1871 to the 'Monthly Microscopical Journal,' * at the close of an article on the aperture question, "Certainly the use of immersion condensers is abundantly indicated in the above simple experiments," and, acting on this indication, he has manufactured a variety of plano-convex, nearly hemispherical, lenses, semi-cylinders, &c., to be placed, with immersion contact, beneath the slide for this purpose.

Besides these devices and various experiments with immersion objectives placed beneath the stage in lieu of the ordinary achromatic condenser, considerable popularity has been enjoyed in the United States by Wenham's reflex illuminator, which its distinguished inventor designed to give black-ground illumination for objects mounted dry,† but which Mr. Samuel Wells, of Boston,

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[*] Vol. vi. p. 36.

[†] Same Journal, vol. vii., 1872, p. 236.

found, in 1875, gave a bright field when used on balsam-mounted objects, provided they were examined with immersion objectives of sufficient angle. Mr. Wells gave an account of this method in the 'Boston Journal of Chemistry,' * in which he says:—"In examining Möller's Probe-Platte, a balsam mount, under these conditions, with light from a kerosene hand-lamp, I easily resolved the *Amphipleura pellucida,* so clear and decided were the lines that with a power of 8000 they were still visible. . . . The resolution of this difficult diatom, as well as the *Frustulia Saxonica* and *Nitzschia curvula* (Nos. 18 and 19 on the Probe-Platte), far surpasses any that I have ever seen by artificial light, and rivals the beautiful resolution obtained by monochromatic sunlight." The paper of Mr. Wells was copied or abstracted in several of our journals, and the method has ever since been in constant use by a number of our microscopists. I note that it has just been rediscovered by Mr. Adolf Schulze, of Glasgow, † who, although apparently unacquainted with the American publication of this method, has arrived at results identical with those of Mr. Wells, as, indeed, all will do who patiently try it with suitable objectives.

I do not claim for my own device, figured in this paper, that it gives better results than the best that can be obtained in this way, or with a suitable hemispherical lens or semi-cylinder, brought into immersion contact beneath the balsam-mounted object; but it is not only cheaper than any of the plans hitherto described, but, as I think, and as all to whom I have shown it seem to find, it is much easier to use so as to get the best results with a fully illuminated field.

In conclusion, I may remark that while it is clearly necessary to use immersion condensers to secure the greatest obliquity of illumination that can be admitted by the widest-angled modern immersion objectives, and while this great obliquity is of substantial advantage in the resolution of lined test-objects mounted in balsam, it by no means follows that such condensers are necessary to the advantageous use of immersion objectives of more than 82° or even of 90° balsam angle, with central light, provided the object is mounted in Canada balsam. The minute details of thin sections of normal and pathological tissues thus mounted and illuminated, are far better displayed by such objectives than by those of inferior angle; and this easily observed fact is so fully in accord with elementary optical theory that its discussion in this place seems quite unnecessary.

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* June, 1875, p. 140.

† "An Easy and Simple Method of Resolving the Finest-lined Balsamed Diatomaceous Tests by transmitted Lamplight, with special reference to *Amphipleura pellucida,*" 'Journal of the Royal Mic. Soc.,' May, 1878, p. 45.

NOTES AND MEMORANDA.

Trembley's Experiments on Turning a Hydra Inside Out.—Professor Th. W. Engelmann, of Utrecht, communicates the following to the 'Zoologischer Anzeiger':—Among Trembley's many remarkable statements concerning the vital properties of *Hydra* none has awakened more surprise than that the animal after being turned inside out continues to live, and is able to take nourishment, to digest, &c. Whilst the statement, if it be correct, would involve the upsetting of many of the most important and apparently best founded morphological and physiological doctrines, yet, on the other hand, Trembley is noted as a most exact and credible observer, and it therefore seemed to me well worth while to repeat his experiments even at the risk of succeeding no better than honest Rösel, the only one I know of who appears to have repeated them carefully.

I have therefore every year since 1873 tried Trembley's experiment, in doing which I narrowly followed his directions. An animal of suitable size and a hog's bristle of proper size and shape, with a pretty steady hand, are all that is wanted. The experiment is by no means difficult. The results, however, were without exception unfavourable to Trembley's assertion.

The turned body of the polyp when it did not soon resume its normal position always perished within a short time, the cells, and first of all those of the entoderm, swelled very much, gradually loosened themselves from their connection, and were found after a day or two like a small white cloud at the bottom of the glass beneath or beside the remainder of the polyp, only the anterior part of the body containing the thread cells, and which consequently cannot be quite turned, remained alive in many cases, and (after the turned part had died and been pushed off) developed a new body from behind, sometimes in a slanting direction. Under the microscope this showed the ectoderm outside, and inside the entoderm, with their known histological structure. In many cases the whole polyp died.

That the conditions were not unfavourable for the success of the experiment, was evident from the fact that under precisely similar circumstances extremely small pieces of the tentacles cut off were frequently observed to develop into perfect five-armed Polypi, and Hydræ, which had been slit longitudinally, to grow together, &c.

For my first experiment I had taken animals from slow-running water. As Trembley's polypi were mostly derived from stagnant waters, I experimented afterwards with such specimens, but with the same negative results. There can therefore be no other conclusion come to than that this otherwise so careful observer has for once been deceived. Certainly if we re-peruse many of his minute descriptions we should like to think that we had done him injustice in this assumption, otherwise we are driven to the further conclusion that he sometimes describes things most minutely of which in reality he has seen the least.*

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* 'Zoologischer Anzeiger,' vol. i. p. 77.

On the Gold Method, and the Termination of the Nerves in the Unstriated Muscles.—Professor Ranvier contributes the following to the French Academy:—Among the methods employed in histology for studying the final ramifications of the nerves, the gold method is the best. It does not, however, give constant results. The old methods of Cohnheim, Gerlach, and Hénocque give clear and demonstrative preparations only by chance. The modification recently introduced by Löwit constitutes a real progress, for by following the procedure of this histologist we succeed much more frequently than by the old process in colouring the nerve fibrillæ, whilst the elements which surround them remain uncoloured or scarcely coloured. There is, however, a grave objection to this process—the solution of formic acid in which the fragment of tissue is placed before submitting it to the action of the chloride of gold, notably alters its delicate parts.

I have therefore sought other methods, and after many fruitless attempts, I have found the following, which nearly always succeeds, at least for some organs:—A cornea, which is an excellent subject for the gold method, is taken from an animal (either a mammal, a batrachian, or a bird) just killed. It is placed for five minutes in fresh lemon juice, filtered; then it is put for fifteen to twenty minutes in three cubic centimetres of a 1 per cent. solution of chloride of gold, then in twenty-five to thirty grammes of distilled water, to which is added one or two drops of ordinary acetic acid. Two or three days afterwards, when under the influence of sunlight and the slightly acid medium the reduction of the gold has been effected in the cornea, preparations are easily obtained, in which the nervous fibrillæ of the connective layer and of the anterior epithelium are excellently shown.

Fragments of striated muscles have been treated in the same manner, or better, after having been subjected to the action of the gold, they have been placed for twelve hours, sheltered from the light, in a solution of formic acid of 20 per cent., and then prepared by teasing. The muscles of the lizards (*Lacerta viridis* and *L. muralis*) have given me terminal nervous arborisations, such as I have never obtained by the process of Löwit. These arborisations, coloured a deep violet, are admirably clear, and show themselves under forms absolutely comparable to those which I have obtained by proof alcohol.

I now come to the important part of this communication, which relates to the termination of the nerves in the unstriated muscles. Histologists are not in accord as to the mode in which the nerves terminate in this kind of muscles. Some, as Trinchese, Frankenhauser, Krause, and Hénocque, while differing on points of detail, maintain that the nerve-fibres terminate upon or in the muscular elements by free extremities; the others, Klebs, J. Arnold, Löwit, and Gschleidlen, admit that the final fibrillæ resulting from the division of the motor nerve constitute a network, but they do not agree on the form, the position, and the extent of this network.

By means of the process above described, I believe I have succeeded in determining the mode of nerve termination in the unstriated muscles. In the voluntary unstriated muscles of the gasteropod mollusca (*Helix pomatia*), the motor nerves are divided and subdivided apparently into fibrillæ, which are lost at the surface of the muscular cells by expanding and forming a terminal arborisation, diminutive and badly defined, to which may be given the name of motor plate (*tache motrice*). In the unstriated and voluntary muscles of the gasteropods there are no anastomoses between the motor nervous fibrillæ; and henceforth a terminal nervous network cannot be admitted in their case. Amongst the mammals, batrachians, reptiles, and annelids, on the contrary, have been observed, in the organic unstriated muscles, a very complex nervous network, but branches of this network disengage themselves from the fibrillæ, mostly very short, which are lost at the surface of the muscular cells, there expanding, and forming an arborisation less clearly defined and still smaller than in the muscles of the gasteropods.

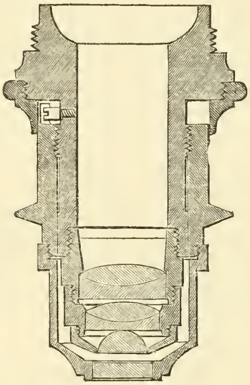
From this somewhat summary explanation—sufficient, however, for what I wish to present to-day—it results that (1) In the unstriated muscles the nerves terminate, as in the striated muscles, at the surface of the muscular elements by an expansion, more or less arborised, of the cylinder-axis. (2) The nervous network of the involuntary unstriated muscles is in connection, not with the elementary nervous action which sets the muscle in activity, but with a more complex action on which depends the functional energy of an organ whose activity is derived from the direct action of the nervous centres. In support of this point I may refer to the fact that the muscular coat of the œsophagus of the mammals, which is formed in great part of striated bundles, but which does not contract under the direct influence of the will of the animal, possesses a plexiform nervous apparatus, and that an apparatus of the same kind appears on the striated musculature of the digestive tube of the anthropods.

It is scarcely necessary now to point out why the different authors who have studied the termination of the nerves in the unstriated muscles, in the different organs and in the different animals, have debated whether the termination is by free extremities or by networks. These networks exist, but in reality they constitute simple plexuses, from which the terminal fibrillæ disengage themselves.

Cover Adjustment for Microscope Objectives.—The present mode of correction adjustment fulfils its purpose only within narrow limits, and beyond these, various secondary faults appear which seriously deteriorate the performance of even otherwise most excellent objectives.

The cause of this imperfection lies in the circumstance that the change in relative distance of the lenses composing the objective, by which the adjustment for cover thickness is at present sought to be effected, affects principally the chromatic aberrations, while the optical influence of the covering glass preponderatingly disturbs the correction of the spherical aberration. For instance, if both aberrations of an objective are corrected in the best manner for such rays as are reflected from an uncovered object, these rays will, as soon as the object is placed under a cover-glass, suffer from a spherical over-correction corresponding to the thickness of the covering glass, while the chromatic aberration is scarcely affected by it. In the adjustment for cover thickness at present, however, the relations of the aberrations are exactly the reverse, for by moving the front lens away from the other lenses of the system, the object-glass will become more chromatically than spherically corrected. An object-glass, therefore, which has been properly corrected for medium cover thickness, for instance, can by means of this adjustment be adjusted so far only as to correct either the spherical aberration absolutely and leave the chromatic aberration under-corrected, or in the most favourable case, under-correct the chromatic aberration, and over-correct the spherical aberration in such a way as to leave both remnants of equal value. Besides this, the distortions spherical as well as chromatic are only at a minimum when the lenses are at a certain relative position to each other; and as in objectives of high angular aperture these defects can anyhow not be quite removed, the extreme position will so increase them as to make not only the distortion and colour appearance at the margin of the field unpleasantly apparent, but to interfere seriously with the definition.

Furthermore, the changing of the relative distances of the lenses composing the object-glass seriously disturbs the focal relation of these lenses, causing a change in the magnifying powers of the magnifying glass which interferes seriously with micrometric measurements.



To obviate all the above-mentioned difficulties, Mr. Gundlach has invented a new cover adjustment for object-glasses, in which he places before the front lens of the objective a transparent disk with parallel sides, capable of being moved by some mechanical means closer to or farther away from the front lens. The general mechanical construction or arrangement of the objective is shown in the accompanying woodcut from the Patent Office Report. In the space intervening between this disk and the front lens he places a transparent fluid of a refracting power equal to, or nearly equal to that of glass, affording thus, by increasing or diminishing the distance between the parallel disk in question and the front lens, and increasing or diminishing thereby the thickness of the layer of refracting fluid between them, a direct compensation for the increased or decreased glass cover of the object, and consequently of the aberrations, without disturbing the focal relations of the lenses of the object-glass, thus avoiding the increased distortions and the disturbance of the magnifying powers of the objective consequent upon and inseparable from the disturbance of the focal relations of the lenses composing the system of the object-glass.

The advantages of this arrangement are obvious, and summarized and recapitulated are as follows:—1. The adjustment exerts no deleterious influence on the corrections of the aberrations, and is equally as efficient for any thickness of the covering glass as for uncovered objects. 2. The working distance is the same for any cover thickness except for immersion objectives; for this reason objectives of very short working distance will with this adjustment admit of even the thickest covering glass. 3. The magnifying power is unchanged. 4. The image is placed but slightly out of focus. 5. The adjustment is very sensitive, thereby facilitating the exact rectification. 6. It can very easily be so arranged that the graduation on the adjustment rim shall indicate exactly the thickness of the cover. 7. Any casual and unavoidable defect in the movement of the adjustment has no influence on the centering of the objective, as any lateral displacement of the parallel disk causes no optical change whatever. The fluid between the front lens and the transparent parallel disk is glycerine, which has so far answered all expectation in a most satisfactory manner. Objectives made seven months ago have been sent long distances by rail without impairing their efficiency, and without loss or renewal of the glycerine. They might perhaps be used for years without the presence of any fluid being suspected. The new adjustment is applicable as well to immersion as to dry working objectives. It deserves to be mentioned, however, that for immersion objectives the advantages of equal working distances for every cover-glass thickness do not exist. It is, however, the reverse of what it is with the old adjustment, as the working distance will be the further the thicker the covering glass happens to be.*

The American Microscopical Congress. — This Congress — it is believed the first of its kind—met at Indianapolis, Ind., on the 14th–17th August last, under the presidency of Dr. R. H. Ward, of Troy. The following papers were read:—

Aug. 14*th.*—"On the Limits of Accuracy in Measurement with the Microscope," by Prof. W. A. Rogers. "Some New Forms of Mounting," by C. C. Merriman.

15*th.*—"On Mechanical Fingers," by C. M. Vorce. "On Angular Aperture of Microscope Objectives," by Dr. Geo. E. Blackham. "On the Definition of the term Angular Aperture," by Prof. R. Hitchcock. "On the Preparation of Ashes of Leaves for the Study of Structure," by Dr. R. H. Ward. "On the Classification of Algæ," by Rev. A. B. Hervey.

16*th.* — "On the Emigration of Blood-corpuscles in Passive Hyperæmia," by Dr. W. T. Belfield. "On a Standard Micrometer," by Prof. R. Hitchcock. "On a handy Rule for Micrometry," by C. M. Vorce. "On the Sting of the Honey Bee," by J. D. Hyatt.

17*th.*—"On a New Section Cutter," by Dr. Carl Seiler. "On Biscol's Section Cutter," by Dr. R. H. Ward. "On the Progress of Microscopic Ruling," by Prof. J. Edwards Smith. "On the Construc-

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* 'American Journal of Microscopy, vol. iii. 135.

tion of Oculars," by W. H. Seaman. "On a New Turn-table," by John Sidle. "On Epithelium," by Wm. H. Atkinson. "On a New Analyzing Eye-piece," and "On a New Arrangement for Dark Field Illumination," by Wm. Lighton.

The afternoon of August 16th was occupied in an excursion round the city, and in the evening a reception and exhibition was held, at which is said to have been exhibited "probably the finest and most imposing display of microscopes, apparatus, and objects ever made in the country."

Before the adjournment of the Congress (to Buffalo, N.Y., in 1879), it resolved itself into a permanent and independent organization, under the name of the "American Society of Microscopists," by the adoption of a constitution, and the election of officers and an executive board of three for the ensuing year, Dr. R. H. Ward being president.

"*Unit of Micrometry.*"—At the American Microscopical Congress, the following resolutions were proposed by Professor Hitchcock, and adopted:—

Resolved,—That this Congress, representing the various Microscopical Societies and microscopists of the country, recommend and adopt, for universal use, from this time forth, the $\frac{1}{100}$ of a millimetre as our unit of micrometry.

Resolved,—That we request each Society of microscopists to formally approve our action in this matter, and to request that all authors of papers conform to these resolutions whenever practicable, and that they may communicate whatever action they may take to the New York Microscopical Society.

Resolved,—That we request microscopical organizations of all countries to formally adopt this same unit, and communicate their action to the same body.

A New Cestoid Host.—Dr. August Gruber, of Freiburg, relates that on accidentally crushing a specimen of *Cyclops brevicaudatus*, under the covering glass he discovered a small worm, which wriggled about in a lively manner beneath it. On examining it he could see plainly a cuticula, and in the interior a great number of calcareous particles. The head was furnished with four well-formed suckers, but was not armed with hooks.

On proceeding to examine a considerable number of these Cyclops, he found that there was quite an epidemic of such small worms affecting the animals. The worms were of all ages, from small, shapeless lumps, visible only under the microscope, to worms which could be seen with the naked eye, about 1 mm. long, and furnished with suckers, cuticula, and calcareous particles.

The creatures were always found in the same part of the cavity of the body of the Cyclops, viz. above the intestines, and, in fact, the larger specimens filled the whole space between the eye and the abdomen, and often penetrated into the latter, but always lay so that the suckers were in the anterior part of the Cyclops. Notwithstanding that such a considerable portion of the bodily cavity was taken up by the parasite, the Cyclops did not seem to suffer much, but moved briskly about in the aquarium; but in specimens where the worm was pretty freely grown the orange-red fat drops which usually filled the animal had disappeared, and the ovaries had become atrophical (the males were not observed to have parasites; they would on account of their small size be destroyed before the worm attained the requisite size.)

As regards the introduction of the parasites, it must be presumed that the eggs of the *Tœnia* are swallowed by the Copepoda, which feed on all kinds of organic matter floating in the water, in whose stomach they hatch, and thence migrate through the walls of the stomach into the cavity of the body. The eggs must be uncommonly small to be taken through the narrow passage between the toothed mandibles into the gullet and stomach.

The worms doubtless become developed into Tænia in the intestines of one of the numerous fishes which feed on the small Crustacea of the sea, and it appears most probable that this parasite, which has chosen such a circumscribed, and for its kind so unusual a domicile, is the young of the *Tœnia torulosa*, which, according to Rudolphi,* infest the Cyprinoideæ of our fresh-water lakes, although I have not succeeded hitherto in finding them.†

On the supposed Radiolarians and Diatomaceœ of the Coal-measures.—Professor W. C. Williamson, F.R.S., called attention, at the Dublin Meeting of the British Association, to the *Traquariœ* of Mr. Carruthers, found in the lower coal-measures of Lancashire and Yorkshire, with small spherical objects that observer believes to be Radiolarians like those still living in existing seas. Professor Williamson showed that the radiating projections with which these spheres are surrounded were not siliceous spines like those of the Radiolariæ, but extensions of a continuous membrane which enclosed the entire organism, and which therefore could not have the spicular nature attributed to them. He then demonstrated that within this external membrane is a second inner one, which latter is filled with numerous small vegetable cells, like others shown to exist in the interior of fossil spores and reproductive cryptogamous capsules found in the same beds as those which furnish the *Traquariœ.*

These conditions are so different from those existing in any known recent species of Radiolarian as to lead Professor Williamson to reject the idea of their Radiolarian character; whilst their close organic resemblance to some obviously vegetable conceptacles found in the same coal-measures suggested that the *Traquariœ* are also vegetable structures.

The mountain limestone deposits of some British localities contain a vast multitude of minute calcareous organisms which Mr. Sollas and other observers have regarded as Radiolarians. These structures, however, seem to exhibit no satisfactory evidence of being so. In the first place these organisms are now calcareous instead of siliceous.

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* 'Hist. Nat. Entozoorum,' ii. p. 111, and Dujardin, 'Helminthes,' p. 584.

† 'Zoologischer Anzeiger,' vol. i. p. 74.

It has been suggested that their siliceous elements were removed and replaced by carbonate of lime, but this appears to be most improbable.

Professor Roscoe and Professor Schorlemmer agree in stating that they would require overwhelming evidence before they would be prepared to accept such an explanation of the present condition of these objects or of the fact of the substitution of carbonate of lime for silica, that such an explanation renders necessary.

Count Castracane has published an account of a process by which he reduced numerous specimens of coals to very minute quantities of coal ash, and has stated that he found in these ashes numerous marine and fresh-water Diatomaceæ. Professor Roscoe kindly allowed one of his ablest assistants in his laboratory at Owens College to prepare analyses of a number of coals according to Count Castracane's method. The residual ashes of these preparations have been mounted microscopically by Professor Williamson, and in no one of them can a trace of a diatom be found. Beyond stating the fact, he is wholly unable to account for the discrepancy between his results and those of the Italian observer; so far as his present observations go, he finds himself compelled to conclude that we have no proof of the existence of Radiolarians or of Diatomaceæ in the British carboniferous rocks.

A short discussion ensued, in which Sir Joseph Hooker, Professor M'Nab, and Dr. Bayley Balfour took part, the views expressed coinciding generally with those of Professor Williamson.

Preservation of Planaria.—Dr. Arnold Lang, of Bern, whilst staying at the zoological station at Naples this year was constantly occupied in the endeavour to find a method of preserving the Planaria which was not only fitted to preserve the exterior form and colour of such tender beings, but would also preserve their histological structure for subsequent sections. He found that pyroligneous acid preserved the form and colour, but destroyed the histological structure; but in an old paper by Blanchard in the 'Annales des Sciences Naturelles' he met with the statement that the writer used "liqueur salin hydrargyrique." He therefore tried chloride of mercury, and succeeded beyond his expectation by using the following mixture:—

100	parts by	weight of	distilled water.
6–10	,,	,,	chloride of sodium.
5–8	,,	,,	acid acet. glac.
3–12	,,	,,	chloride of mercury.
(½	,,	,,	alum).

The process is as follows:—A perfect specimen is carefully placed in a shallow cup of sea-water, and laid on its back. This being done, the sea-water is removed by means of a pipette, so that the worm lies stretched out flat; a sufficient quantity of the mixture is then poured on its abdominal side, when it at first draws itself together a little, but immediately afterwards extends itself, and dies almost directly, stiffened in its natural shape. Any wrinkles that may be formed can easily be straightened with a brush. Half an hour afterwards the mixture is to be removed by a pipette, and 70 per cent. alcohol added, in two hours 90 per cent. alcohol, and, later on, absolute alcohol. In two days all the specimens will be found to be quite hardened. When stained (he recommends picrocarmine in pretty weak solution, and soaking for several days), all the Planaria thus treated preserve their histological structure perfectly well. There is inconvenience in imbedding in paraffin, as in consequence of the great wrinkling the parenchyma of the body is torn asunder. However, by gradually applying turpentine in a strong solution of paraffin this wrinkling can be avoided.

By this method the most delicate Planaria, as e. g. *Leptoplana*, *Proceros aurantiacus*, *cristatus*, *Thysanozoon*, &c., can be prepared so as to partly retain the colours they possessed when living.*

"*Commercial Microscopy.*"—At the "Écoles Supérieures de Commerce et d'Industrie" of Rouen has been established a course of instruction on the application of the microscope to commercial purposes. Dr. Pennetier, the Director of the Museum of Natural History at Rouen, who has taken charge of the course from its commencement, has addressed a note to the 'Journal de Micrographie,' detailing the objects he has had in view and the specially satisfactory results hitherto obtained, and urging upon the other commercial schools of the country that they should follow the initiative of Rouen and establish a similar course. Many of the pupils of the Rouen school have owed their admission to the large industrial establishments to the expertness in microscopical manipulation which they acquired under Dr. Pennetier's instruction. It is intended to publish the Doctor's lectures, which include not only the adulterations of food, but the recognition of the nature and proportion of the different kinds of fibres in particular materials, the origin and quality of the hairs employed in hat making and the fur trade, the raw material of which any given paper is composed, the discrimination of true ivory from the substances used for it, and a variety of similar matters. This subject also formed the basis of the recent address of the President of the Quekett Microscopical Club.

Physiology of the Contractile Vacuoles of the Infusoria.—The following observations made by Professor Th. W. Engelmann are adduced by him as demonstrating what hitherto has only been a matter of conjecture, that the contractile reservoirs of the Infusoria empty their contents externally on contracting. A new Infusorium which he was examining (which may be called *Chilodon propellens*), was the size of a medium specimen of *Chilodon cucullulus*, and accords with this species also in the limitation of the stripes and cilia on the ventral surface, as also in the presence of a discharging cytostom, in the anterior third of the body, and a simple nucleus in conformity with it. The shape is, however, slender, and towards the posterior end, in which the large contractile bladder is placed, the body is more roundly turned. Thus an approach is made of the hypotrichous to the holotrichous type, which is interesting from a systematic point of view.

The animal swam about with a generally constant but very

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* 'Zoologischer Anzeiger,' vol. i. p. 14.

slight motion, for the most part in slight curves. Whenever the contractile reservoir became contracted, which occurred pretty regularly at intervals of about half a minute, and took place very suddenly, there succeeded a jerking kind of acceleration of the forward movement. If the animal happened to be previously stationary, it made a jerking forward movement at the instant of the systole of about a quarter its length. A simultaneous acceleration of the very sluggish ciliar motion could not be discerned at all. The phenomenon can only be explained, therefore, by the rebound caused by the fluid ejected from the contractile bladder at the systole.

With this harmonizes the fact that the hindermost section of the body shrunk together at the systole into a thin, empty, longitudinally folded sac, without there being any appearance of even the slightest increase of volume of the front part of the body. It is certain, therefore, in the case before us, that a very large portion, perhaps the whole quantity, of the fluid contents of the contractile bladder was emptied outwards during the systole.

As the re-expansion of the bladder, as is generally the case, took place very slowly, it could not be decided whether any fluid could be directly sucked in from without. He considers this, however, to be highly improbable, amongst other reasons, because he never succeeded even with other species in seeing the contractile vacuoles fill themselves with coloured fluid from that which surrounded them.*

White of Egg as an Imbedding Substance.—The best substance for imbedding small objects with a view to the preparation of sections is one that can be hardened to any required degree, is easily cut, is transparent, and allows of the section being placed in balsam or dammar immediately after it is prepared.

These requisites are found in the ordinary white of egg of the fowl.

The object to be imbedded (which is best stained beforehand) must have lain for one or more hours, according to its size and penetrability, in white of egg, so as to become thoroughly penetrated by it. There must be no alcohol left in the object, as it gives rise to blisters in the course of the subsequent process, and thereby produces holes in the imbedding substance.

The object thus soaked is now placed in an oblong box of stiff close-made paper folded or pasted together filled with the albumen. The position of the object may be fixed if necessary by a needle passing through the upper part of the box, which can be easily withdrawn after the hardening.

The box thus filled must be exposed to hot steam or, still better, to hot air. After about twenty minutes the albumen becomes hard enough, and the box should then be put into strong spirit, which in the course of a few days must be changed once or twice, to be finally replaced by absolute alcohol. Several days after this treatment the objects are ready for cutting. The paper walls of the box may be removed with a knife, and a section of the hardened albumen several

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* 'Zoologischer Anzeiger,' vol. i. p. 121.

millimetres thick taken off, which can be afterwards used for pinning small objects on before placing them in the box.

The dried (dehydrated) pieces can now be cut by the microtome into sections $\frac{1}{80}$ mm. thick, and the section placed at once on the glass slide, where it may be treated as usual with oil of cloves and balsam. If the mass is too hard, it can be softened to any degree by laying it in water. It is far better, however, to let it lie before cutting for a day in oil of cloves (or turpentine), where it becomes transparent as amber, but at the same time a little softer, though still hard enough to be fixed in the microtome.

The imbedding substance appears under the microscope either perfectly homogeneous or in the worst case very finely granulated.

The advantages of this method are that complete series of sections can be permanently produced without much loss of time, and without the different parts of the object being removed from their position, whilst the transparency allows of uninterrupted observation of the position of the object. Moreover, the object need not be so carefully hardened as is required in paraffin. The method is strongly recommended for calcareous and siliceous sponges as well as for worms and the embryos of fowls.*

New American Journal of Microscopy.—Professor Romyn Hitchcock, of New York, announces that it is intended to issue, under his editorship, a quarterly journal, with the title of the 'American Quarterly Microscopical Journal.' It is to contain, "besides original articles from prominent writers, reprints and translations of the most important papers found in current English, French, and German publications, the Transactions of the New York Microscopical Society, and a complete synopsis of all microscopical matters; and to this end abstracts will be given of every article published during each quarter to which the editor has access, or where abstracts are inadmissible, titles of the papers will be given." The journal is to be "absolutely independent of any business enterprise, and published entirely in the interests of microscopical science."

Anaerobiosis of Micro-Organisms.—The following note by M. Gunning was read at the French Academy on 1st July:—At the meeting of the Academy of Sciences of Amsterdam of the 29th April, 1877, I pointed out that ferrous ferrocyanide was a reagent very sensible to oxygen, and demonstrated by this means that the apparatus and media ordinarily in use for the culture of micro-organisms could not be exempt from oxygen by the methods recommended for that end.

These observations threw a legitimate doubt on the experiments on which the doctrine of anaerobiosis is based, and I have naturally been led to repeat these experiments under conditions which allow this new point of view to be taken account of. Admitting the practical impossibility of obtaining spaces where the absolute absence of oxygen could be proved, I have used glass flasks hermetically sealed, in

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* Prof. Selenka, in 'Zoologischer Anzeiger,' vol. i. p. 130.

which as large quantities as possible of putrescible matter were placed in contact with the smallest possible quantities of oxygen.

The matters which I made use of, viz. urine, blood, soup, yeast, and milk, as well as water and raw meat, and grains of rice, beans, peas, pieces of coagulated albumen, &c., taken in a fresh state, were infected by bacteria taken from similar matters in a state of full putrefaction. The flasks were then sealed and exposed to a temperature of 38–40 degrees; putrefaction was immediately established, to be definitely arrested, however, in all the flasks after a longer or shorter period, often very short, but always sensibly proportional to the quantity of oxygen which was supposed to be present. I have had in my possession for nearly two years a considerable number of these flasks whose contents have lost little or nothing of their primitive freshness.

The details of these experiments are related in a memoir which has been published in the 'Annals of the Academy of Sciences, Amsterdam,' vol. xii., 1878, and in the sixth part for the year 1878 of the 'Journal of Practical Chemistry,' as well as the arguments which led me to attribute the cessation of the putrefaction solely to the death of the bacteria caused by the absence of free oxygen.

I will ask permission to cite here one of these arguments, because it relates especially to a subject which has often occupied this Academy.

When the flasks containing the putrescible matters terminate in tubes provided with cotton-wool, or are re-curved many times upon themselves, and whose tapered points are hermetically sealed, we are able at any given moment by breaking the point to expose the contents anew to the contact of the air, deprived of germs. If to establish this contact we wait for the moment when the contents have arrived at a state of complete inertia, we observe that the air no longer produces the least phenomenon of putrefaction or appreciable alteration. This proves in my opinion not only that the bacteria as well as their germs are really dead, but also that the organic matters are not susceptible of spontaneously producing others. These experiments are then, as it seems to me, very strong arguments against archebiosis, and so much the more that the organic matters are not subjected here to any other manipulation than the seclusion during several days or weeks of the air—a manipulation which produces no alteration either in colour, structure, or solubility, and which seems to preserve them as much as possible in their natural state.

This is why I have applied this method to the well-known experiments of M. Bastian with urine neutralized by potash; my procedure was the same as his, with this difference, that no measures were taken to sterilize the matter operated on; on the contrary, it was mixed with a drop of urine in full putrefaction. A certain number of flasks of about 500 cubic centimetres capacity were filled as completely as possible with this prepared urine, then sealed and exposed to a temperature of 40°. The urine got thick, but became perfectly limpid again at the end of some days; it then remained in this state without change of colour and without presenting any other sign of alteration. Other flasks arranged in the same manner, but whose tapered necks terminated in orifices of different size, allowed me to observe not only that the putrefaction was clearly established, but that its intensity was sensibly proportional to the quantity of air which could enter. It was easy in this way to set up putrefaction at all degrees, from zero to the maximum, in different portions of the same matter eminently putrescible and infected, whose conditions of existence presented no other difference than that of the greater or less free access of air.

Urine neutralized by potash must be considered a matter eminently fit for the life of micro-organisms, and extremely difficult to sterilize by the ordinary methods; but from the moment when the organisms which it contains no longer find oxygen, they lose completely the faculty of supporting the bacteria, and with greater reason the faculty of producing others.

The seclusion of oxygen offers a simple means, generally applicable and efficacious, for sterilizing organic matters, and furnishes the most conclusive proofs against spontaneous generation.

M. Pasteur, after the above communication had been read, made the following remarks:—It is seventeen years since I published the first facts relative to life without air or anaerobiosis; since this time I have occupied myself with the cause of error which the author refers to in the preceding note, and notwithstanding the very great precision, as I think, of my first experiments, I have always endeavoured since then to make this precision more perfect. Very recently, on the occasion of the remarks which I published in conjunction with Messrs. Joubert and Chamberland, we carried still further the investigation of the means proper for eliminating in a complete manner the air from our flasks. With this end we combined the action of the vacuum of the mercury air-pump with the properties of white indigo, a substance so well known for its effect in the absorption of oxygen since the work of M. Dumas on the subject.

If the author of the preceding note will go further in his observation, if he will remark, as he does not seem to have done, that putrefaction is often arrested not by the death of the microscopic organisms, but because they have passed to the state of germs, I do not doubt but that he will be led, as was the case with Dr. Brefeld in regard to the development of alcoholic yeast, to retract his assertions, and to recognize that the existence of anaerobic beings rests on irrefutable proofs.

In the second part of his note M. Gunning combats the conclusion of Dr. Bastian on spontaneous generation, and I am glad of the confirmation which he brings to the arguments which I have already used against the latter gentleman.

Haliphysema Tumanowiczii, not a Sponge.—In the July number of the 'Annals of Nat. Hist.,' Mr. W. Saville Kent records the results of an examination he has made at Jersey of some specimens of this organism found on the fronds and root-stalk of *Maugeria sanguinea*, in regard to which so much controversy has arisen.

Prior to the discovery of the living specimens, Mr. Kent had made an examination of a dried one, which, though not definitely solving the question, had tended to confirm an affinity to the sponges, within the interior being found one or more minute fragments which bore a strong resemblance, under a magnification of 800 diameters, to a pavement-like arrangement of the essential collar-bearing spongozoa in a desiccated state.

When the living specimens were obtained they were in the first place transferred to a shallow zoophyte trough, and cursorily reconnoitred with a power of from 100 to 200 diameters only. This preliminary inspection yielded no positive results, the spicule-bristling capitulum in each instance maintaining the mute stolidity of the sphinx itself, and altogether refusing to yield up its secret. In one or two instances, however, there was the ghost of an appearance of syncitium-like sarcode embracing the base of some of the larger spicules. At the same time (and this must be accepted as a somewhat significant fact) not the slightest inward or outward current from the terminal orifice or any other region could be detected on adding a solution of carmine to the water, which may be almost immediately observed when experimenting in a similar manner on a living sponge. Proceeding now to a more intimate acquaintance with the organism, a lucky cut with a dissecting knife had the gratifying result of dividing a specimen evenly and longitudinally from one end to the other; and this, submitted to no higher a magnifying power than the one previously employed, at once solved the riddle. Cord-like prolongations of moving granular sarcode were seen at the severed edges extending from one to another of the projecting surfaces of the quartz granules or spicular fragments of which the skeletal framework was composed. Here and there these cord-like prolongations were, as it were, knotted into fusiform or globular dilatations, and these, by the contraction in opposite directions of the thinner portions, were now and then drawn slowly across from one end to the other of the same. The sarcode substance of the more interior portion corresponded closely with that of the knotted dilatations, except that in this more densely aggregated condition it presented a darker amber-like aspect. In a little while still finer thread-like extensions of this sarcode were thrust out from the denser mass, some as slender, attenuate, simple filaments, while others assumed a more or less branching form. Here and there the ramifications of these latter came into contact and anastomosed with one another, while in all was maintained a circulation of the granular contents identical in all ways with what obtains among the typical Foraminifera, such as *Miliola* and *Rotalia*. A still more rigid examination with the aid of a magnifying power of from 800 to as much as 2000 diameters failed to reveal the existence of any structures corresponding with the collar-bearing flagellate zooids of ordinary sponges, or, indeed, of any separate cellular elements whatever. Occasionally the globular or fusiform sarcode dilatations already mentioned exhibited, under this increased magnifying power, the presence within their interior of a nuclear-like body and sundry vacuoles, as represented in the plate accompanying the article. Beyond this, all consisted of a homogeneous, interblending, and adherent granular sarcode, showing in its attenuate condition that granule-circulation just described. The Foraminiferal nature of the organism and the accuracy of Mr. Carter's first deductions relating thereto, were now therefore established beyond dispute, and it has now, it may be anticipated, found a permanent resting-place among the arenaceous, and in this case adherent test-building Foraminifera represented by Dr. Carpenter's family of the Lituolida.

Mr. Kent then details the capture and digestion by the animal of the nauplian larva of a crustacean which still more clearly established its true nature, and describes the characters presented by the external test or skeletal portion.

Through the artificial preservation for several weeks of living specimens some knowledge of their developmental history was obtained, and every gradational step from the naked pyriform zooid to the test-constructing and matured condition was observed.

The Embryology of Sponges.—Mr. Kent, at pp. 139–156 of the same volume, records the results of an extended personal investigation of the so-called "ciliated embryos," or "larvæ," or "reproductive gemmules" of sponges. Whilst Metschnikoff, Carter, Oscar Schmidt, F. E. Schultze, and Barrois agree with one another, and so far with Haeckel, in according to these bodies the existence of two or more distinct cellular layers, carrying with it the inference that sponges are true tissue-forming Metazoa, Mr. Kent considers the sponges to be "compound colony-building, collar-bearing flagellate monads, exhibiting neither in their embryological nor adult condition phenomena that do not find their parallel among the simple unicellular Protozoa," and he regards "the so-called 'ciliated embryos' as the equivalent not of a single body or person, but as a special aggregation of innumerable individuals, to which collectively the title of 'compound ciliated gemmules' or 'swarm-gemmules,' may be most appropriately applied. The chain of evidence supporting this decision" follows, as the result of which Mr. Kent submits that the developmental manifestations of the ciliated sponge embryo make it clearly evident that we have here "merely a mode of increase, for a special purpose, by multiple fission differing in no essential manner from that common to *Magosphæra*, and the independent collar-bearing types, such as *Salpingœca*, and the majority of the Infusoria flagellata. That these bodies cannot in any way be compared with the true ova of the ordinary Metazoa is demonstrated not only by their inconstant form and character disassociated also with any act of spermatic fecundation, but from the fact that the segmentation of the primary unit gives rise to a morula-like aggregation which does not develop by the fusion of its constituent particles or blastomeres into a single germ-lamella or blastoderm, but into a number of distinct and independent unicellular zooids or units. The metazoic interpretation of the nature of sponges, as grounded upon the developmental manifestations of these same bodies, must likewise, as a consequence, be abandoned or otherwise be extended to the simple Monadina, Radiolaria and Catallacta, which produce a similar morula-like segmentation-mass, thus leaving the Protozoa in possession only of little more than an empty title. The true nature and significance of the so-called ciliated embryos of the sponge, while not reconcilable with the proposed metazoic interpretation, becomes clearly intelligible on collating these organisms with the unicellular Protozoa. Regarded from this position, the identity of the ovate aggregation of separate units which constitute the so-called sponge-embryo with the similar aggregation of units of the segmented monad, afterwards separated and dispersed as swarm-spores, is made apparent. This sponge-embryo is in this manner demonstrated to be merely an aggregation of swarm-spores held closely bound to one another throughout the process of development—a 'swarm-gemmule,' whose mission it is, in its aggregate condition, to lay the foundation of a composite sponge-stock similar to the one which gave it birth, and in manner identical with that individually effected by each motile swarm-spore of the solitary monad.

As a final demonstration of the protozoic nature of sponges, the multiplication of these organisms by the production of countless infinitesimal spores after the manner of the typical Monadina, has been determined. This spore-formation is brought about through the assumption by the matured collar-bearing zooids of a quiescent encysted state, accompanied or not by the fusion of two individuals. The spores produced by the breaking up into almost invisibly minute particles of the entire protoplasmic substance of the encysted zooids, are liberated in the substance of the syncytium; and within this matrix each spore develops again through an amœboid or cytoblastic, and then simply flagellate, phase to an adult collar-bearing unit. The multiplication of the typical sponge monads or Spongozoa by the means of spores represents the constant and normal manner in which the growth and extension of the sponge-colony is effected; the aggregated masses of individuals or swarm-gemmules, liberated only at certain periods, representing a special development for the more extensive dissemination of the species."

Osmic Acid.—With reference to Dr. Pelletan's recommendation of osmic acid for the purpose of fixing Rotifers, Infusoria, &c., with their organs extended (see p. 189), the following note from the August number of the 'Journal de Micrographie' may be quoted:—"Osmic acid is a reagent the employment of which requires some precautions. It is very volatile, its vapour has a very disagreeable odour, is very poisonous, very irritating, and may cause serious injuries to the eyes. It is found commercially in the form of crystals, in small tubes hermetically sealed. The two points of the tube should be broken, and the crystals put into a known weight of distilled water. If the weight of the tube when empty is deducted from its weight when full, that of the crystallized acid is known, and consequently the strength of the solution, which can then be diluted with distilled water as may be required. The solutions may be preserved in flasks closed with sealing-wax, which can be softened by a heated metallic rod at the time of use. A little of the solution may be taken out with a pipette, and the flask closed again with the sealing-wax. Small quantities of the solution can be preserved for immediate requirements in stoppered bottles.

The "Transporter" of Professor Monnier.—This is employed in the Laboratory of Microscopy of the University of Geneva, and is intended to facilitate a rather delicate operation in the preparation of objects for the microscope. Everyone knows how difficult it sometimes is to place the covering glass on a preparation, in glycerine for example, without introducing bubbles of air or deranging the object already placed, with much trouble, in the desired position. With this apparatus the thin glass is "transported" automatically upon the preparation by means of a very simple mechanism.

The "Transporter" is more especially destined for preparations in glass cells, but it will serve also for other cells. It is composed of a small rectangular wooden plate, to one of the long sides of which is fixed by two hinges a wooden lever, like a small flat ruler, with a semicircular bifurcation at the end, where it is attached to the side of the plate in order to secure it better. By the hinges it can be brought down on the plate, or raised perpendicularly, or even turned over on the other side upon the table.

On the plate are two clips of brass, the distance between which can be altered as desired, and which are intended to receive between them, and to fix in an invariable position, the glass slides of different sizes on which the preparation is to be placed.

The hinged lever carries on its under side just above the fork a piece of brass with two uprights, through which a horizontal screw works. On the screw are two small nuts, which, on turning the screw, approach to or recede from each other. Each of the nuts carries a small peg of wood.

Suppose now that the cell has been fixed to the slide. The latter is then placed on the plate and secured between the two clips so that it cannot move; then on the still empty cell is placed the covering-glass exactly in the place that it should ultimately occupy. The lever is then brought down to the plate, without, however, touching the covering glass, the two nuts being then just over it. In order to regulate their distance apart, the screw is turned so that the two small pegs of wood are *vis-à-vis* the two opposite sides of the cell, but a little inside them. The apparatus is then adjusted for cells of the same size. If now a little glutinous matter is placed on the ends of the wooden pegs and the lever is brought down so that they touch the covering glass, at the same time applying slight pressure, the latter will remain fixed to the pegs when the lever is raised again and turned back on the table.

The preparation can then be proceeded with, taking care not to move the slide. After the object is put in its place in the preservative liquid, the lever is brought gently down, and will then replace the covering glass exactly in the position that it was in previously. Before raising the lever again the covering glass must be kept in its place with the handle of a knife, &c., so that it is not taken up again with the pegs.*

Fungus of the Maple (Rhytisma acerinum).—The maple frequently has black spots on its leaves during the summer, caused by a para-

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* 'Journal de Micrographie,' vol. ii. p. 285.

sitic fungus, *Xyloma acerinum*, which constitutes a special type of affection. This is only an imperfect and summer form; when the leaves fall in the autumn a further growth takes place in the spots; the plant acquires thecæ and becomes *Rhytisma acerinum.*

In the same locality the spots appear every year. Is the parasite perennial as some Uredinæ (*Æcidium Euphorbiæ sylvaticæ* and a great number of Pucciniæ)? Is it annual like the *Rœstelia* and the greater part of the *Æcidia?* Sown in one point, does it spread through the plant like *Endophyllum Sempervivi*, *Peronospora Papaveris*, &c.?

Some very young shoots of maple were placed in several flowerpots; two had each eight, and were a reserve, the others, each containing four, were used for experimenting.

On the 1st April, 1874, some mature spots of *Rhytisma* were cut into narrow strips like tobacco, and wetted, and then in small heaps placed in contact with the young maples. All parts are not equally fit for the introduction of the parasite: *Ustilago carbo* penetrates by the collum, *Crystopus candidus* by the cotyledons. Direct anatomical investigation of the mode of introduction of the germs is rendered extremely difficult by the form of the spores, which are very elongated, by their diameter and that of the germinal filaments, which are very slender, but above all by the irregularity of the germination.

Four experiments were made to determine the mode of penetration. The small heap was placed:—

A. Round the collum at the level of the soil.

B. In the fold of a cotyledon rolled up and maintained in that position by a pin. Each of the two pots was covered over with another soaked with water to prevent desiccation, vapour, and the removal of the spores by the wind.

None of the leaves showed any *Rhytisma* either in 1874 or the following years.

C. In the cleft of two cotyledons, on the leaves of the terminal bud, at that time little developed.

D. Between the leaves of the terminal bud already raised by the stem. The cotyledons were smeared with suet down to their base in order to isolate them; they soon withered and fell. The plants, although vigorous at the beginning, remained more slender than the others.

In the two latter cases the *Rhytisma* appeared after two and a half months. The spots were at first white and greenish grey, then turned black in places, and finally over their whole surface. In the middle of July the spot was completely formed.

The plants were shown to M. Brongniart, M. Duchartre, M. Roze, and several other botanists. In the autumn all the leaves which fell were collected. The following year, and since, the parasite did not show itself; it appears therefore to be annual. It seems also to be very narrowly localized. In the plants experimented on, the lower leaves, the only ones then developed, were alone spotted; the spots were all in the same state; the mycelium did not spread.

In 1876 I attempted to mark out on the leaves (not very young, but already large) some lines and crosses by means of the *Rhytisma.*

The spots commenced to show themselves, but the tissue withered on all the leaves: the parasites only developed in a very incomplete manner, and did not appear the following year. The fungus is therefore entirely localized on the foliar and deciduous organs; it is fully developed only on the young organs.

It appears then that it would be sufficient to produce the disappearance of the *Rhytisma* to destroy all the spotted leaves which fall in the autumn, but this presupposes that the small corpuscles (spermatia of Tulasne), produced in enormous numbers on the living leaves (*Xyloma*), are not able also to produce the parasite.

The red spots of the plum tree, produced by the *Polystigma rubrum*, an ascomycetous fungus of quite another group, and much more dangerous, have probably a very analogous history.*

The Reproduction of Hydra (Note by M. Korotneff, communicated by M. de Lacaze Duthiers to the French Academy).—" In spite of its abundance, the fresh-water Hydra presents a great number of peculiarities insufficiently studied, and particularly the reproduction of the sexual elements, and the embryonic development of the individual itself.

These phenomena have been described in a fairly detailed manner by Kleinenberg, in his 'Monograph of Hydra.' According to his researches, the cells are found below the ectodermal elements (*interstitielles Gewebe*), and form an agglomeration which serves to reproduce the ova as well as the spermatozoids. The development of the ovum is accomplished as follows: one of the cells of the agglomeration increases remarkably, and swallows up the surrounding cells —in other words, it feeds itself upon them. The nucleus is changed into a germinal vesicle, and at last, the cell itself represents the ovum of the *Hydra*, which is thus, according to its origin, a monocellular and ectodermic formation.

The granulations of a definitively formed ovum serve to produce the larger elements, which Kleinenberg describes under the name of pseudo-cells (*Pseudocellen*, Kl.).

After a detailed description of the segmentation, the German savant passes to the formation of the blastoderm, as an immediately succeeding phenomenon to segmentation. The blastoderm consists of a layer of cells, forming by itself the entire envelope of the ovum. Kleinenberg considers the blastoderm to be an embryonic epithelium, not taking part in the ulterior formation of the Hydra, and thrown off as an envelope at a certain period of the development; for this reason the adult Hydra is an animal destitute of epithelium.

My own researches, made upon *Hydra fusca*, completely contradict those of Kleinenberg. Nevertheless, conformably with his researches, I have seen an agglomeration of cells, of ectodermic elements, which I consider simply embryonic cells, which serve to reproduce different ectodermic elements. One of these cells grows, and its nucleus changes into a germinal vesicle. At the same time, the peripheral elements of the agglomeration separate, forming a row

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* M. Max Cornu, in 'Comptes Rendus,' vol. lxxxvii. p. 178.

of cells by means of small, highly refractive granules, while the central cells are joined to each other and to the enlarged cell; in this manner, a common plasmodium is formed, strewn with a considerable number of nuclei. The germinal vesicle begins to degenerate, and disappears entirely (this last phenomenon agrees with the observations of Kleinenberg); but the nuclei of the central cells undergo a transformation of another sort; they increase somewhat in size and degenerate into fatty bodies; at the same time certain of them divide (their nucleoli also take part in this division). The degeneration of a nucleus begins by a considerable increase of its nucleolus, which becomes highly refractive and ends by being blended with the contents of the nucleus. It is these degenerated nuclei, probably serving for the nutrition of the embryo, which Kleinenberg takes for pseudo-cells. The peripheral elements of the agglomeration, strewn with granules of a chitinous origin, serve to form the shell or the envelope of the ovum.

In comparing my observations with those of Kleinenberg, I conclude that the German savant has taken the peripheral cells of the agglomeration for a blastoderm, and the mass of central cells for an effect of segmentation of the ovum. According to my observations, *Hydra* evidently cannot be regarded as an animal destitute of epithelium: my former researches have established the fact that this epithelium is muscular." *

The Staining and Preparation of Bacteria.—In the 'Zeitschrift für Mikroskopie' Dr. W. A. Haupt explains his views as to how the staining and preparation of bacteria may be facilitated.

After referring to the development in recent times of the doctrine of a *contagium vivum*, and the fact that scarcely a medical periodical can be taken up but we meet with articles on the etiology of infectious diseases with reference to bacteria, Dr. Haupt complains that from the inexperience of the authors or their defective microscopical observations these articles tend rather to obscure than elucidate the subject. He instances a paper by Dr. Tschamer which appeared in the same journal, in which hooping cough is attributed to the presence of the *Ustilago Maydis*, and its oidium from *Capnodium Citri*. Dr. Haupt maintains that the *Ustilaginæ* have not the oidium form, and that this parasite being found exclusively on maize, it is strange that the disease should flourish where there is no maize, and be rare where it is cultivated in abundance. It is far more probable, he thinks, that it is produced by a kind of *Micrococcus* similar to the *Micrococcus diphthericus*. The presence of spores and fungi in cases where there is no hooping cough is a fact known to everyone who has had much to do with the microscopical examination of the contents of the oral cavity, and, as a case in point, Dr. Haupt relates how, together with *Micrococcus diphthericus*, &c., he found spores of *Tilletia caries* in the pus taken from a boy who was suffering from diphtheria. These, he concluded, had nothing to do with the disease, but were attributable to the atmosphere in which the boy lived being impreg-

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* 'Comptes Rendus,' vol. lxxxvii. p. 412.

nated with flour dust, and, on inquiry, he learned that the boy's father was a pastry-cook.

The difficulties which are involved in the study of bacteria arise partly from the gaps which appear in the classification of these minutest of all living organisms and the new forms which are continually cropping up, and partly from the microscopes employed, although furnished with high powers, possessing little power of illumination and definition, whilst the investigation of bacteria is a matter of enormous difficulty on account of their extreme minuteness, their weak refracting power, and their motion. By Dr. Koch's process, however, photographs of bacteria will be obtained showing not only their contours, but any flagella or other details, and thus correcting the false ideas founded on erroneous drawings, and paving the way to fresh discoveries. It is confidently predicted that in many kinds of pathogeny where a morphological distinction cannot be discerned, but which are the cause of complaints of a most diverse nature, there will be quite characteristic differences discovered.

Dr. Haupt speaks in the highest terms of Dr. Koch's method, but says that for the practical physician it is too tedious and troublesome. His modification if it consists in staining the whole fluid which contains the bacteria, instead of each preparation by itself. This involves but little expenditure of time and trouble, and can be done at the patient's bedside or at the dissecting table if he be provided with a bottle in which to put the substance to be stained, and another containing the staining fluid. The microscopical examination may be subsequently made at any convenient time, and the bacteria are as clearly seen as when Koch's method is used.

The fluids which Dr. Haupt employed were carmine, eosin, rose de Magdala, hæmatoxylin, parme, anilin-violet, fuchsin, and erythrusin, and, except with the first two, he obtained good results. Hæmatoxylin stained *Micrococcus* very quickly. He recommends as best anilin-violet, fuchsin, and especially erythrusin.

Bacterium termo, though difficult of preparation, should be first experimented with, as what answers with it will succeed with all bacteria. *Bacterium termo* is easily procured by exposing a piece of raw meat placed with water in a porcelain cup to the sun for an hour or two, or letting it stand near a warm oven. When an opal-like scum has formed on the fluid, every drop is seen under the microscope to contain millions of these bodies.

This or any other fluid containing bacteria (urine, serum, blood, &c.), should be put in a 10-gramme glass which has been carefully washed and rinsed with alcohol. The bottle should be a fourth or a fifth part filled, and the same quantity of a solution in water (well filtered) of the staining material added, and then, after being well shaken, it is to be corked and labelled. It is well to write on the label its contents, date, and hour. With some objects the staining is effected in five, ten, or fifteen minutes, others require twenty-four to forty-eight hours. After being assured by examination with the microscope that the result is satisfactory, a drop is then taken by means of a pipette from the bottom, and spread out well on a glass slide and dried in a warm place (well protected from dust), which takes about ten or fifteen minutes. A drop of dammar varnish or Canada balsam is added to it, and the covering glass pressed down as much as possible. The preparation is then ready.

As compared with preparations made by Dr. Koch's method, the ground appears a little more coloured. Since, however, the bacteria are considerably darker, and as high powers must necessarily be used, in which case the colour of the ground causes no inconvenience, the method is strongly recommended to those who have a limited time to devote to microscopical manipulating.*

A Mineralogical Microscope.—M. Renard describes, in the 'Bulletin of the Belgian Microscopical Society,' a new microscope intended for the examination of microscopic crystals by polarized light. One of the leading pecularities of its construction consists in the contrivance (apparently adopted for economical reasons) by which the objective is centered upon the object on a rotating stage. The tube of the microscope carrying the object-glass is enclosed in a fixed outer tube, which is contracted at the upper part so as not to allow of any "pivoting" of the inner tube at that end. Below the contracted part there is a space between the outer and inner tubes, the former being lined with parchment, which is pressed against the latter by springs. Through the lower end of the outer tube work two screws at right angles to each other, which press against the inner tube and move it in two rectangular directions (or any intermediate one), so that it can be readily brought into the correct position.

Alcoholic Fermentation.—An interesting series of experiments was lately instituted by Herr Muntz, in order to determine whether the living cells of the more highly organized plants, when entirely cut off from oxygen, are equally able with the cells of fungi to produce alcoholic fermentation. For this purpose he experimented with a variety of plants, beet, maize, cabbage, chicory, portulacca, nettles, &c. From each kind three equally healthy plants were selected. One was left in the open air, and the other two were placed, with the accompanying soil, under capacious bell-glasses containing an atmosphere of nitrogen, the oxygen being removed by pyrogallic acid. After a lapse of from twelve to forty-eight hours, they were removed from the glasses. One was placed in the open air in order to be certain that the power of development was retained after the imprisonment, and the other was cut off above the ground, distilled with water, and tested for alcohol. In all cases the plants which had been in an atmosphere free from oxygen showed appreciable quantities of alcohol, amounting often to a thousandth of the entire weight of the plant, while no traces could be detected in the plant which had remained in the air during the same time.†

Alcoholic Fermentation.—M. Berthelot recently published, in the 'Revue Scientifique,' what purported to be a copy of some notes (written in October 1877), which were found after his death amongst the papers

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* 'Zeitschrift für Mikroskopie,' vol. i. p. 175.

† 'Nature,' vol. xviii. p. 504.

of the late Claude Bernard. These notes, to quote M. Pasteur's words, "are an absolute condemnation, without any restriction, of my views on the subject of fermentation in general, and alcoholic fermentation in particular." M. Pasteur took the matter up with some warmth, and the 'Comptes Rendus' of 22nd and 29th July contain two communications which he made to the Academy, together with the rejoinders of M. Berthelot. M. Pasteur considers he has established that the notes of M. Bernard refer to experiments only just commenced, and which Bernard intended to repeat and check. This view M. Berthelot does not appear to controvert. M. Pasteur concludes by saying that "he is resolved to repeat the experiments of Claude Bernard, and that on a scale and with a fulness of results worthy of the subject and the respect due to the deceased. M. Berthelot applauds this resolution, and anticipates beneficial results to science, "which lives by observations and contradictions. Since the discoveries of M. Pasteur have fixed our ideas of the origin and multiplication of the organized beings which propagate fermentations, a new problem has been presented. The point is to know whether the chemical change produced in every fermentation is not resolved into a fundamental reaction, excited by a definite special principle of the order of soluble ferments, which in general consumes itself proportionately to its production—that is, transforms itself chemically during the very accomplishment of the result which it causes. To recognize such a ferment, we must know how to isolate it; that is, to ascertain the special conditions under which the soluble ferment is secreted in a greater proportion than it is consumed.

The definite relation between the soluble ferment and the microscopic being which forms it has been pointed out, I believe, for the first time with precision, in my researches on the inverting ferment contained in the cells of beer-yeast. It has been found since in the ammoniacal fermentation of urea and elsewhere. It may be well to examine now whether it can be extended to alcoholic fermentation itself—that is, whether some particular condition can be discovered such as those which Claude Bernard seems to have perceived—a condition in which the matter which provokes the alcoholic decomposition of the sugar is formed in an excessive proportion, and consequently capable of being isolated. Alcoholic fermentation would then, as is the case already with most of the others, be brought back to the purely chemical actions."

The Structure of the Brain in different Orders of Insects.—The Supplementary vol. xxx. of Siebold and Kölliker's 'Zeitschrift für Wissenschaftliche Zoologie,' contains an elaborate article by J. H. L. Flögel, illustrated by a number of microphotographs. This and Dietl's excellent paper, published in 1876, are the only treatises on the minute structure of the brain of insects, Owskianikof having studied that of the spiny lobster *Palinurus* several years ago, while Dietl studied the brain of *Astacus*. Flögel establishes three points as the results of his researches.

First, the constant presence of the remarkable central body in the mature insects of all orders, while it is almost absent in the larvæ of

Lepidoptera (but not in Hymenopterous larvæ). We are thus led to suppose that it has something to do with the formation of the faceted eyes. If it has any relation with the bundle of fibres passing from the optic lobe, there is nothing to indicate it.

Secondly, the size of the olfactory lobe, with its olfactory bodies, correlated in insects with small antennæ entirely unfit for tasting, but on the contrary, with a very completely developed sense of smell, is in the author's opinion an excellent proof of the correctness of Leydig's view that the antennæ are organs of smell, whatever may be brought forward in opposition to it. If they are to be interpreted as an apparatus for detecting sounds, we, on the other hand, are acquainted with the finer structure of the organs of hearing in the Orthoptera, and know that they have no such constituted brain-centres as the olfactory lobes.

Thirdly, Flögel draws attention to the wonderful and so little understood facts that in insects, where the lobes ("bechers" of Flögel, "lappen," "gestielte körper," &c., of Dietl) and the substance around them (gerüst) constitute the greater part of the brain, there is indeed no connection of the nerve-fibres to be found with the remaining parts of the brain, and consequently also with the œsophageal commissures. The opinion that the ganglionic cells are in direct relation through fibres with the organs of the body is provisionally unfortunately contradicted. But where are the intermediate stations? he asks.

Finally, the author claims that the essay indicates the outlines of a future brain topography for insects, and shows that the single parts of the brain have their homologues in the different orders of insects; consequently a ground-plan in the organization is not to be mistaken, and thus a comparative anatomy of the brain of insects is outlined comparable with that of the vertebrates, as established by the researches of Stieda.*

The Movement of Microscopic Particles suspended in Liquids.—In Section A. (Mathematical and Physical) of the British Association's recent Meeting, the following paper, entitled 'Note on the Pedetic Action of Soap,' by Professor W. Stanley Jevons, was read:—"Since the publication in the 'Quarterly Journal of Science' for April, 1878, of my paper on Pedesis, or the so-called Brownian movement of microscopic particles, it has been suggested to me that soap would form a good critical substance for experiment in relation to this phenomenon. It is the opinion of Professor Barrett and some other physicists, that the movement is due to surface tension, whereas I believe that chemical and electromotive actions can alone explain the long-continued and extraordinary motions exhibited by minute particles of almost all substances under proper conditions. Soap considerably reduces the tension of water in which it is dissolved, without much affecting (as is said) its electric conductibility. If, then, pedesis be due to surface-tension, we should expect the motion to be killed or much lessened when soap is added to water.

Having tried the experiment, I find that the result is of the

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* 'American Naturalist,' vol. xii. p. 616.

opposite character to what Professor Barrett anticipated. With a solution of common soap the pedetic motion becomes considerably more marked than before. I have observed this result not only with china clay and some other silicates, but also with such comparatively inert substances as the red oxide of iron, chalk, and even the heavy powder of barium carbonate. The last-named substance, one of those which we should least expect to dance about of its own accord, gave a beautiful exhibition of the movement when mixed with a solution of about 1 per cent. of soap, and viewed with a magnifying power of 500 or 1000 diameters.

The correctness of this result was also tested by observing the suspending power of solutions of soap-solution compared with water. If a little china clay be diffused through common impure water, that, for instance, of the London Water Companies, the greater part of the clay will soon be seen to collect together in small flocks and fall to the bottom in two or three hours, the water being almost clear. However, if about 1 per cent. be dissolved in the water, the behaviour of the clay is quite different. The larger particles soon subside, but the smaller ones remain diffused through the liquid for a long time, giving it a milky appearance, quite different from the flocky and grainy appearance of the common water; if 1 per cent. of sodium carbonate be dissolved in common water, and china clay be mixed therewith, the subsidence of the clay is still more rapid, owing, as I have explained, to the increase in the electric conductivity of the fluid, and the consequent decrease of the pedesis. But I now find that if soap be added at the same time, pedesis is not destroyed, but considerably increased, and the clay remains a long time in suspension, two or three days at least.

These facts give a complete explanation of the detergent power of soap. It has long seemed to me unaccountable that for cleansing purposes the comparatively neutral soap should be better than the alkaline carbonate by itself; we are told that the alkali is but feebly combined with the stearic or other fatty acids. But why combine it at all if we need only the alkaline power of the base? The fact is, that the detergent action of soap is due to pedesis, by which minute particles are loosened and diffused through the water so as to be readily carried off. Pure rain or distilled water has a high cleansing power, because it produces pedesis in a high degree. The hardness of impure water arises from the vast decrease of pedesis due to the salts in solution. Hence the inferior cleansing power of such water. If alkaline salts be added, dissolved in water, it becomes capable of acting upon oleaginous matter, but the pedetic power is lessened, not increased. But if the soap be added also, we have the advantage both of the alkali dissolving power, and of the pedetic cleansing power. At the same time we have a clear explanation why silicate of soda is now largely used in making soap; for I have shown, in the paper referred to, that silicated soda is one of the few universal substances which increase the pedetic and suspensive power of water.

I believe that the detergent power of soap and water is one of the many important phenomena which may be explained by the study of pedesis, and I propose to follow up the investigation of this movement in regard to the several substances which tend to increase it."

The Preparation of Thin Sections of Objects of different Consistency. —In investigating the anatomy of corals Mr. G. von Koch, of Darmstadt found the calcareous skeleton one of the greatest drawbacks to his researches, as it often prevented any observations of the structure of these animals. Sections of decalcified pieces give good results only in special cases. Generally the decalcifying and still more the succeeding operations so disarrange the separate parts that their original relative positions can scarcely be recognized, and the structure of the calcareous parts is of course entirely lost. He applied the following method to overcome the difficulties, and obtained preparations that would show very clearly the structure, form, and position of the different elements. Pieces as small as possible of the object to be cut are stained thoroughly, and after rinsing, all water is got rid of by means of weak and afterwards proof alcohol. The pieces are then put in a cup filled with a very thin solution of copal in chloroform. (This is easily made as follows:—Pound the coarse pieces of broken copal in a mortar with fine sand, pour chloroform over the fine powder thus obtained, and filter the solution.) Then slowly evaporate the copal solution by putting the cup on a piece of pottery ware, which is warmed by a common night-light. The slower the evaporation the better. When the solution can be drawn up in threads which become brittle on cooling, the pieces are taken out of the cup, and laid for some days on the ware to harden quicker. When they have become so hard that the edge of the finger-nails makes no impression, cut the pieces into thin sections with a saw, and grind them smooth and flat on an ordinary sharpening stone. Then cement the plates by their smooth sides to a slide by means of Canada balsam or copal varnish, and lay them again on the warm plate. After some days, when the preparation has become firmly fixed, grind it first on a revolving grindstone (or a flat one), and then on a sharpening stone until the section has acquired the right thinness. Wash the section well with water and add Canada balsam, and cover with a covering glass.

If it is desired to show small quantities of organized substances in calcified tissues, the section is treated as above; but before the covering glass is put on it, it should be placed in chloroform till all the resin is drawn out, then carefully decalcified, and last of all coloured. The organic parts can be represented still more beautifully and without the least change of position if the section, as described above, is freed of resin, then cemented with very thick Canada balsam to a slide, and the exposed half only carefully decalcified, then washed and stained. By this means he succeeded in showing, for example, the most delicate connective-substance-lamellæ in the skeleton of *Isis elongata*.*

Measurement of the Dihedral Angles of Microscopic Crystals.—M. Em. Bertrand, whose paper on this subject, presented to the French

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* 'Zoologischer Anzeiger,' vol. i. p. 36.

Academy, will be found at p. 217, has contributed some further remarks on the subject to the 'Bulletin of the Mineralogical Society of France,' of which the following is a translation, omitting those parts which repeat what has already appeared in the 'Comptes Rendus.'

"The eye-piece which enables the observer to make sure that one of the faces of the crystal has its projection perpendicular to the zero plane (described in the previous article), has been slightly modified with the view of obtaining greater sensibility. It is composed of a cylinder of flint of 6 centimetres long, to the middle of which is fixed, by Canada balsam, a plate of crown of the $\frac{1}{6}$th of a millimetre thick. The flint having a greater, and the crown a smaller refractive index than that of the balsam, it will be seen that the upper part of the cylinder being placed at the focus of the upper lens of the eye-piece, two reticles will appear very close and parallel, and the interior of these two reticles will be illuminated if the face of the crystal has its projection perpendicular to the zero plane of the microscope. However little the crystal is turned to the right or left from this position, the part comprised between the two reticles will cease to be illuminated, whilst the exterior part will be more strongly illuminated either on the right or left according as the crystal has been turned.

The possible error is given by the value of the angle whose sine is $\frac{1}{310}$; this angle is less than 10′, and as two readings can be made by turning the crystal to the right or left successively until the interval between the two reticles is completely darkened, the error is reduced to 5′.

Measurements made on crystals of $\frac{1}{20}$ to $\frac{1}{30}$ of a millimetre have given results correct within 6′.

The smaller the face of the crystal is, the greater, of course, will be the sensibility of the process. If a face is observed which is not very small, this face will reflect light into the microscope obliquely to the optic axis of the apparatus even when the projection of the face of the crystal on the horizontal plane is perpendicular to the zero plane, and this oblique light will destroy the clearness of the phenomenon; whilst if the face is very small, all the light reflected by it will be sensibly parallel to the zero plane of the microscope. Moreover, when the face of the crystal is not very large, its image is seen in the microscope on both sides of the double reticle when this face has its projection perpendicular to the zero plane; but on a slight rotation of the stage to one side or the other of the correct position, the image disappears either to the right or the left of the double reticle, and remains visible on one side only. This disappearance of one half of the image in conjunction with the extinction of the part comprised between the two reticles renders the observation very easy. It is sufficient therefore to employ magnifying powers proportionate to the size of the crystal, so that the sides of the face observed should appear in the microscope to be about 2 mm. The difficulty in the use of high powers is their short focus, which prevents good illumination. Crystals of about $\frac{1}{100}$ mm. may be measured, but for smaller ones the process ceases to be applicable."

M. Bertrand also explains his mode of illumination to be to place a luminous slit of about 30 centimetres long before the microscope very exactly in the zero plane, which illuminates the crystal from the horizontal direction up to one of about 70°. By a mirror applied horizontally to the cube the crystal can be illuminated with the same slit by means of the reflected rays from the horizontal direction to one about 70° downwards. In this way there will always be a luminous point reflected by the crystal along the axis of the microscope, provided that the face of the crystal makes with the stage an angle between 10° and 80°, and as it is sufficient to measure two of the angles a, b, c, and two of the angles α, β, γ, the measurement will always be possible, for if the face of the crystal should make with one of the faces of the cube an angle less than 10° or greater than 80°, this face will make with two other faces of the cube an angle comprised between 10° and 80°.

The Microscope applied to the Phenomena of Double Refraction.—In the same article M. Bertrand describes a method which he makes use of when greater sensibility is required than is obtained by the use of two crossed Nicols only. This consists of a thin plate made of four sections of quartz, alternately right and left handed, placed in the eye-piece of the microscope. This plate, of about 2½ mm. in thickness, gives between the crossed Nicols a field slightly bluish and uniformly illuminated; but when a doubly refracting body is examined, the four sections present colours alternately blue and yellow, except in the position in which, by the ordinary method of observation, the field would be dark. In this latter case the sections remain uniformly illuminated, and of the same tint.

This method is, on the whole, much more sensitive than that of simple extinction, inasmuch as two different colours, illuminated and side by side, have to be compared; whilst when we have to estimate what is the position which gives the maximum extinction, two obscurities are compared, not by the side of each other, but one after the other. The same object can, however, be observed by the ordinary method of extinction and by that now described (using either the ordinary or the quartz eye-piece), and thus the results checked.

The Causes of Buzzing in Insects.—M. J. Perez is the author of the following:—

"Since the experiments of Chabrier, Burmeister, Landois, &c., the buzzing of insects has been ascribed to the vibrations of the air rubbing against the edges of the stigmatic orifices of the thorax, under the action of the motor muscles of the wings. These latter organs play only a very small part in the phenomenon by modifying more or less the sound produced by the respiratory organs.

I have repeated all the experiments of these authors: they have not always given me the results stated, or I have thought it possible to draw from them a conclusion different from theirs.

1. It is quite true that by sticking together the wings of a fly (*Sarcophaga carnaria*) as Chabrier has done, we do not prevent the sound from being produced; but it is not the fact that the wings can thus be kept completely motionless. The flexibility of these organs enables them at their base, where free, to obey the contractions of

the muscles of flight; this base vibrates and the buzzing is produced. But all buzzing ceases if any movement of these organs is rendered impossible, by holding the wings tightly pressed together over as large a surface as possible, so as to exert a certain strain on their base. In whatever manner the wings are held, provided that they are completely motionless, the buzzing ceases absolutely, contrary to the opinion of Hunter.

2. By removing the scaly parts with which the circumference of the stigmata is fringed, the buzzing, far from being annulled, as Chabrier affirms, is not in any way modified, provided that the operation has not weakened the animal sensibly.

3. The respiratory organs may be injured in different ways, and more or less seriously; solid bodies of considerable size may be introduced, without preventing the buzzing or changing its 'timbre.'

4. If the thoracic stigmata are hermetically closed, as Burmeister has done, the buzzing is not in any way extinguished; it is only weakened in proportion to the weakening of the flight itself.

There are then produced, especially among the Diptera, effects which deserve notice. The animal becomes slow and lazy; it no longer willingly flies. If it does so, its ill-sustained flight is not long before it stops, then the insect succumbs and no longer gives signs of life.

I once saw an Eristal (*E. tenax*), which having briskly escaped from my fingers, towards the window, immediately after the closing of the stigmata, fell motionless at my feet, entirely exhausted by a flight of a few centimetres. This result does not always follow so suddenly, but it never fails to supervene after a few repeated attempts at flight. It is easily explained by the complete absorption of the provision of oxygen contained in the tracheæ of the thorax, in consequence of the contractions of the muscles of flight. It is a true asphyxia. At the expiration of some minutes, however, the fly returns to life, owing to the influx of air through the abdomen into the thorax. The animal may then again attempt to fly, or at least to walk, but it is never long before death finally supervenes. These effects are so constant and so easily obtained, that it is really surprising that no experimenter has noticed them.

The causes of the buzzing certainly reside in the wings. It has been recognized for a long time that the cutting of these organs, effected more or less close to their insertion, exercises a more or less marked influence on the buzzing. It becomes thinner and sharper; the *timbre* itself is considerably modified. It loses the mellowness due to the friction of the air on the edges of the wings, and becomes in some degree nasal. The *timbre* perceived under these circumstances recalls that of certain reed instruments, or, better still, that of certain electrical contact-breakers, and in no way resembles the sound which the passage of air through an orifice may produce. This sound, on the contrary, agrees entirely with the repeated beatings of the wing-stump against the solid parts which surround it, or of the horny pieces which it contains (*osselets radicaux* of Chabrier) against each other.

If a slightly fluid substance, which only dries slowly in the air, is coated over the wing-stump of an animal, operated upon in the manner just described, the preceding sound is sensibly deadened, without the stigmata being in any way modified, or the movement of the wings impeded.

When the section includes the stump itself, the sound becomes sharper and weaker. It ceases as soon as a sensitive part is reached; but, as may easily be made evident, it is only because the animal then ceases to execute movements which have become painful.

To sum up, in the Hymenoptera and the Diptera the buzzing is due to two distinct causes; the one being the vibrations of which the articulation of the wing is the seat, and which constitute the real buzzing; the other, the friction of the wings against the air, an effect which more or less modifies the former. It would not be impossible, after these data, to reproduce artificially the buzzing of these animals, and I have some hope of succeeding.

Among the powerful-winged Lepidoptera, such as the Sphinxes, the soft and mellow humming which these animals make is only due to the rustling of the air by their wings. This sound, always grave, is the only one produced; it is not accompanied by basilary beatings, owing to a special organization, and chiefly to the presence of scales.

Among the Libellulæ also, the base of whose wings is furnished with soft and fleshy parts, there does not exist any real buzzing, but a simple noise due to the rustling of the organs of flight." *

Although the following paragraph has now gone the round of the provincial (and some London) papers, having appeared in the 'Times' of 17th September, it will not be inappropriate to reprint it here in juxtaposition with the above note of M. Perez which appeared in the 'Comptes Rendus' of 2nd September:—

"The old naturalists thought generally that the buzzing of insects was produced by the vibrations of the wing, but they had scarcely attempted to analyze this phenomenon, and their opinion was abandoned when Réaumur showed that when the wings are cut a blow-fly continues to buzz. Other explanations of the phenomenon have been advanced by various naturalists, but none of them are satisfactory. M. Jousset de Bellesme has been making some investigations on the subject, and, after proving that previous theories are unsatisfactory, he describes the results of his own researches. To avoid confusion, it should be distinctly understood what is meant by buzzing. In the scientific acceptation it means to imitate the sound of the humble-bee, which is the type of buzzing insects. But the humble-bee gives out two very different sounds, which are an octave of each other—a grave sound when it flies and a sharp sound when it alights. We say, then, that buzzing is the faculty of insects to produced two sounds at an octave. This definition limits the phenomenon to the Hymenoptera and the Diptera. The Coleoptera often produce in flying a grave and dull sound, but they are powerless to emit the sharp sound, and consequently do not buzz. There are two or three ascertained facts which will serve as guides in the interpretation of the phenomenon. First, it is indis-

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* 'Comptes Rendus,' vol. lxxxvii. p. 378.

putable that the grave sound always accompanies the great vibrations of the wings, which serve for the translation of the insect. It is easily seen that this sound commences as soon as the wings begin to move, and that if the wings be cut off it disappears entirely. The sharp sound is never, on the contrary, produced during flight; it is only observed apart from the great vibrations of the wings when the insect alights, or when it is held so as to hinder its movement, and in that case the wing is seen to be animated by a rapid trembling. It is also produced when the wings are entirely taken away. From these two remarks we may draw the conclusion that the grave sound belongs properly to the wings, that it is caused by their movements of great amplitude. There is here no difficulty. As to the sharp sound, it is certainly not produced by the wings, since it survives the absence of these. Yet the wings participate in it and undergo a particular trembling during the production of this sound. To discover the cause it is necessary to go back to the mechanism of the movement of the wing. It is known that among nearly all insects the muscles which serve for flight are not inserted in the wing itself, but in the parts of the thorax which support it, and that it is the movement of these which acts on the wing and makes it vibrate. The form of the thorax changes with each movement of the wing under the influence of the contraction of the thoracic muscles. The muscular masses intended for flight being very powerful, this vibratory movement of the thorax is very intense, as may be proved by holding one of these insects between the fingers. But as the vibrations are repeated two or three hundred times per second, they give rise to a musical sound, which is the sharp note. In fact, the air which surrounds the thorax is set in vibration by that directly, and without the wing taking part in it. There are then two simultaneous sounds, one produced by the vibration of the wings and the other by the thoracic vibration, the latter twice as rapid as the former, and therefore an octave. This is why in flight only a single grave sound is heard. When the thorax moves alone, a sharp sound is produced. This, M. de Bellesme believes, is the only explanation that can be given of the mode of production of the two sounds which constitute buzzing."*

The Septicity of Putrefied Blood.—The following note was presented to the French Academy in July by M. V. Feltz:—"I showed experimentally in 1875 that putrefied septic blood subjected for several days to the contact (or passage) of pure oxygen seems to become less poisonous, and that it differs from the initial blood by a diminution of the movements of the vibrions. I also established in 1877 that pure oxygen compressed at a high tension during thirty and fifty days destroyed the oscillating rods and the vibrions of putrefied blood, but that it had no effect on the corpuscular germs or conoidal spores, which explains the power of the septicity. I have had the good fortune to agree on this point with M. Pasteur, who expresses himself thus in his 'Theory of Germs:'—

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* Apparently a summary of a paper read before the French Association for the Advancement of the Sciences, in August.

'The vibrion is killed by the oxygen, and it is only when it is in bulk that it is transformed in presence of this gas into corpuscular germs, and that its virulence can perpetuate itself.'

Compressed oxygen killing the adult vibrions, I have desired to know whether it would not also kill the germs by keeping up the compression at high tension for a longer time.

Conclusion: The action of oxygen compressed at a high tension and maintained for a long time, acts upon putrefied septic blood in the same way as a temperature of 150°. It destroys the vibrions and the germs in which the septicity of the liquid is inherent."*

Escape of small Animals from Aquaria.—The following simple method of preventing small animals which swim about in an aquarium being carried away with the water has been successfully employed in the zoological station of Naples. The water is conducted away, either by a tube proceeding from the bottom of the basin to the surface, or by a siphon having the end of discharge bent up again to the desired water-level. In order that the small animals may not be carried away by the stream flowing through the tube or the siphon, these latter are surrounded by a cylinder whose lower end is sunk into the sand covering the bottom, whilst the upper end projects above the surface of the water. By this means the water is filtered by the sand before it reaches the orifice of the tube which draws it off. As regards the width of the cylinder, it is to be remarked that with coarse sand and a weak stream it need not be large; on the other hand, the stronger the stream is, and the finer the sand, the larger ought the cylinder to be, to allow as much water to flow away as is introduced in the same time. In applying the siphon as above described, it is advisable not to let the end which draws off the water reach the bottom of the aquarium, as otherwise sand might be drawn up into the siphon, and possibly stop it up. It is sufficient if the inner arm reach to the level of the bend in the outer arm.†

A New Form of Micrometer.—In No. 37 of the 'Journal of the Quekett Microscopical Club,' Mr. G. J. Burch explains in detail the construction and use of a micrometer which he has devised, and which he claims to be easy to make and equal in accuracy to all other micrometers except the Cobweb.

The principle on which it is based, is the comparison of the reflection of a scale with the image of the object. It consists of a cap fitting over the eye-piece, containing a piece of neutral-tint glass (or looking glass, with the amalgam removed in the centre) set diagonally, so as to reflect to the eye the image of a scale which is carried by an arm ten inches long attached to the cap, the object being observed through the eye-piece in the usual way.

To adjust the scale so that it may read decimals of an inch, &c., it is moved on the arm nearer to, or further from the eye, till on adjusting the focus so that the apparent distance of the two images may

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* 'Comptes Rendus,' vol. lxxxvii. p. 117.

† Dr. Spengel in 'Zoologischer Anzeiger,' vol. i. p. 106.

coincide, every tenth division on the scale shall cover the $\frac{1}{100}$th or $\frac{1}{1000}$th of the stage micrometer according to the power used.

The Nutrition of Insects.—"I undertook, in September 1877, a series of researches on the nutrition of invertebrate animals, especially insects. My studies bore on the gaseous exchanges with the atmosphere at different periods of metamorphosis.

I shall only call the attention of the Academy at present to the variations in the weight of the animal, above all, in the nymph or chrysalis state, in which the excreta are almost entirely gaseous.

If we trace a curve, taking for abscissæ the times, and for ordinates the weights, from the egg to the perfect state, we find:—

1. In the larval state the ordinates grow rapidly, to a maximum which corresponds to the moment when the larva ceases to feed; the curve has the form of a sinusöid, with a few irregularities at the times of casting the skin; beyond the maximum the ordinates decrease, forming a descending branch of another sinusöid.

2. This curve continues during the early times of the nymph; but starting from the 'confirmed state' of M. Dufour, when, in the Lepidoptera and Diptera which I studied (*Bombyx mori*, *Musca vomitoria*, &c.), the weight is reduced to half the value which it had attained in the larva, the variations become much smaller, the curve is changed into a straight line slightly inclined to the axis which represents the times; the inclination always increases in the latter days of the nymph.

3. At the moment of escape, there is an abrupt diminution of weight by the loss of the envelopes. During the short state of immaturity there are rapid alternations of augmentation and diminution of weight. (Here follows a diagram of the curve.)

4. In the perfect state and when the animal is taking food, there are successive augmentations of weight, which may reach and surpass the maximum weight of the larva, and become almost triple what it was at the time of escape; there are, moreover, temporary variations of this weight, in different conditions of movement or repose, of light or darkness, &c. In the animal subjected to starvation from the time of escape, death supervenes after a loss of weight, which in different individuals belonging to the same species, is a sensibly constant fraction—among the Diptera about half the initial weight.

The investigations above mentioned as to the gaseous exchanges, allow of the explanation of the greater number of these facts, which throw light on the physiology of invertebrate animals."*

Parasites on a Diatom.—M. Guimard, a corresponding member of the Belgian Microscopical Society, communicated to the Society, at their July meeting, a circumstance that he observed in examining some diatoms, mostly consisting of *Pinnularia*, which he gathered at the seaside. He was astonished to see a great number of the diatoms covered by small bodies of a yellowish brown colour, and moving with great rapidity. With a No. 5 of Nachet they were seen to have

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* M. L. Joulin, in 'Comptes Rendus,' vol. lxxxvii. p. 334.

a rectangular body, and contained in their interior a yellowish brown matter, with globules of a deeper colour, and resembling the ordinary endochrome of the diatoms. At each of the four angles was a long hyaline arm, of great mobility. Seen in profile, the body presented the form of an elongated oval. M. Guimard, who considers them to be parasites, adds that they were endowed with extraordinary agility, and by means of their long and flexible appendages explored all the parts of the frustules. A woodcut accompanies the paper.*

Mode of Development of the Tentacles in Hydra.—Mr. Mereschkowsky recently expressed the opinion that the fundamental number of the organs in the Hydroids (that is the number which enters into the composition of all the other numbers) was not four, but two, arriving at this opinion partly from facts which had shown him that the appearance and sometimes the disappearance of the organs takes place so that they appear or disappear simultaneously two at a time. Observations on the mode of production of the tentacles in *Hydra vulgaris* and *H. oligactis*, he considers, serve to confirm this opinion, and to establish a general law which governs the formation and the order of appearance of every organ in this class.

The order of the appearance of the tentacles he finds as the result of his observations (which extended to three complete pairs) to be this:—

The first two appear at the same time and (what is especially remarkable) are arranged opposite to each other; the others also appear in pairs, and are also arranged opposite one another; they do not, however, appear together, the second tentacle of each pair always appears later than the first, and this retardation is much greater in the third pair than in the second.

This curious mode of appearance of the tentacles in the genus is, so far as known to the author, peculiar to it, and does not occur elsewhere among the Hydroida, in which we observe three types of development, viz.:—(1) Appearance in pairs; (2) Appearance by four at a time; and (3) Appearance of all the tentacles at once, as for example in *Tubularia*. This exceptional case would serve very well to explain the fact (which is also exceptional) that in *Hydra* we very often observe the number seven, which does not accord with the formula $2 \times n$ that in general characterizes all the Cœlenterata. In fact, if the sixth tentacle does not appear until long after the fifth, we may expect that in the fourth pair of tentacles the seventh will appear earlier than the eighth, and that this last will be delayed much more than was the sixth. It is in this way that we find a variable number of tentacles in the different species of *Hydra*, sometimes six, seven, eight, or even more. It may well be supposed that the individual sometimes dies before having had time to acquire an eighth tentacle. But there is no reason for thinking that the number of tentacles in *Hydra* is subject to such variations that it cannot be governed by any law. We may easily see that the facts are subjected to a general law, although, owing to their great complexity, the law does not strike one at once,

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* 'Bulletin de la Société Belge de Microscopie,' vol. iv. p. 304.

and can only be ascertained by carefully studying the genesis of the animals.*

Fluid Mounting.—At the April Meeting of the Microscopical Section of the Troy (U.S.) Scientific Association, the Rev. A. B. Hervey described a method, which he had recently devised. In his study of the Algæ and Lichens he had been troubled, as others have been, by the difficulty of permanently mounting specimens while studying them, without waste of time or change of arrangements. Most of the methods of mounting either ruin such objects entirely or else require considerable time, care, and special appliances that are troublesome to a busy student, and therefore instructive specimens are lost. The objects may be transferred from water to Farrant's solution of gum and glycerine, and mounted without delay; but the structure is not well preserved, and air bubbles are likely to be obstinately present. The objects show best in distilled water, sea-water, camphor-water, &c.; and to mount them instantly and with uniform success he prepares cells of the gum and glycerine solution put on by means of the turn-table in the usual way. Having made cells of the required depth, and laid them aside until thoroughly dry, the inner half of the width of the cell is varnished on the turn-table with gold size, which is also allowed time to dry perfectly. Objects in water are arranged and covered in these cells with ease, and are ready after lying aside for a time varying from a few minutes to a few hours, to receive a coat of gold size or other varnish, the fluid that exudes from the cell in pressing down the cover-glass having dissolved enough of the gum cell to hold the cover in position. It has not been found that the cell is too much affected by the fluid; but if it should be so, the cell could be made of the usual cements, insoluble in water, and then coated with a thin layer of gum.†

Influence of Temperature on the Optical Constants of Glass.—In an article in the 'American Journal of Science and Arts' (April), Mr. C. S. Hastings gives the results of some investigations which he has made on this subject. "The most surprising fact," he considers, "which these results point out is that the variation in dispersive power attending variation in temperature is relatively enormously greater than that of the refractive power, a fact which has, he believes, escaped attention heretofore. It could hardly have escaped unheeded, however, did not a singular relation obtain in the coefficients. The dispersive powers of three specimens of glass (flint, sp. gr. 3·554; do. sp. gr. 3·151; crown, sp. gr. 2·482) computed in the ordinary way, are as 9 : 8 : 6 nearly, while the coefficients in question are as 9 : 6 : 5 nearly; hence if this relation holds approximately for all optical glasses, as is probable, an achromatic combination good for one temperature is good for all others within moderate limits."

Protecting Cap for Focussing under Water.—This, which was described in 'M. M. J.,' vol. viii. p. 44, appears to have been recently re-invented, under the name of "Dudgeon's Submersion Cap."

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* 'Ann. and Mag. Nat. Hist.,' ser. v. vol. ii. p. 251.

† 'The American Naturalist,' vol. xii. p. 333.

The Optic Rod in the Crustacea and Annelida.—The following are the "conclusions" of M. Joannes Chatin, in his article on this subject in the 'Annales des Sciences Naturelles' (Zoology), 6th series, vol. vii. p. 31:—

"In attempting to sum up the principal results, we see that the optic rod of the Crustacea presents general characters which are constant in the whole class, and also arrangements either special or of variable importance which differ according to the types examined. This should suffice to show the danger of the method too often followed, and according to which the observation of a few insects may furnish results capable of being immediately extended to the whole of the Arthropoda.

Limited externally by the 'cornea,' terminating internally in the ganglion of the optic nerve, the rod presents two very distinct parts, of which the characters as well as the importance differ notably—the one, internal and more or less slender, deserves more especially the name of *rod;* the other, external, short and swollen, but of variable shape, is the *cone.*

It is needless to recall here the general characters of the latter, and the signification of the central line in which it has been attempted to show the analogue of the filament of Ritter; but as far as regards the rod, I insist particularly on the value which it is proper to attribute to its transversal striæ, which do not in any way indicate a contractile tunic, but are proper to the rod which may be separated into a certain number of disks thus marked out. This disposition establishes a close relationship between the optic rod of the Articulata, and the rod of the Vertebrata.*

Such is, in short, the structure of the rod in the generality of the class; if we go back to the different types studied, the principal forms which it there presents can easily be recalled. In *Astacus, Squilla, Pagurus, Eupagurus,* and *Paguristes,* rods are met with, whose constitution is really higher, as many details show. The *Cypridina* offer analogous dispositions, but seem, however, to tend towards a close histological simplification; this is particularly marked in *Typton,* and more clearly still in *Lysianassa,* where the rod shows no transversal striæ and the cellules of Semper are represented only by a dark spot, from an early period of development.

Notopterophorus and *Caprella* scarcely differ from the types last studied, but as much cannot be said of *Epimeria,* in which the organic degradation is marked in a considerable degree, and leads to extremely simple forms which in *Lichomolgus* become still more rudimentary.

This rapid outline reminds us of the manner in which the study of the Crustacea has led us progressively to more and more simple bacillary elements. Moreover, and without wishing to enter here into the discussion of the theories to which I allude, we know the important part which many contemporary zoologists accord to the existing too heterogeneous series of Worms, whose *ensemble* would constitute a kind of 'groupe de depart' allied by a close affinity to

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* It is known that the researches of Boll have recently confirmed my own observations.

other branches. This opinion seems especially defensible when we examine the visual organ, which may, in these species, assume very distinct forms, and some of which recall the eyes of the Mollusca or of the Vertebrata, whilst others may be compared to the optic point of lower animals. These considerations have naturally led me to investigate whether in this group of Worms some types might not be met with, possessing rods analogous to those of the Crustacea.

The results which are found to justify this hypothesis are known. Among the Vermilia we have found eyes exactly comparable to those of the *Lichomolgus*, and reduced to two elements so similar to the rod of the Crustacea, that the same name cannot be withheld from them. Among *Protula*, *Psygmobranchus*, &c., one alone of these bodies suffices to constitute the organ, whilst the study of *Dasychone* recalls a more elevated form, that of *Epimeria*, for example.

Often among the Crustacea, as I have mentioned with reference to the *Lichomolgus*, &c., the rods may originate from a common pigmentiferous base. But what is such an arrangement if not the exact representation of that presented to us by various worms (*Protula intestinum*, *Vermilia clavigera*, &c.)? The analogies go on multiplying in this way as one advances in the study, and thus show in the strongest manner the close relationship which exists between the optical elements of these diverse animals.

Such are the principal results of my researches; these, however, must not be regarded as forming a complete history of the optic rod, to the study of which I have only attempted to bring some new facts. I hope soon to be able to complete them by a new series of observations and experiments instituted with the view to the study of the development of the rod, and to determine what characters and what relations it may present in the different ocular forms."

The Minute Structure of Stromatopora and its Allies.—Professor H. Alleyne Nicholson and Dr. J. Murie have made a lengthy communication to the Linnean Society on the above subject. *Stromatopora* they point out, even at the present moment, occupies a most unsettled and uncertain position, while hints and doubts flow freely as to whether it be allied to the Calcareous or the Siliceous Sponges, to the Foraminifera, to the Corals, to the Hydrozoa, or to the Polyzoa, or whether it may not be a heterogeneous assemblage of dissimilar forms, or perhaps the representative of a special and now extinct group of organisms. Unfortunately, the animal itself cannot be appealed to as affording evidence towards the solution of this problem, the remains of its habitation, or its skeletal structures alone offering data upon which any judgment on this disputed point may be arrived at. Their object is to present the results of a careful examination of a large number of specimens and sections of different forms of *Stromatopora* and of related groups. These results, it is hoped, will serve to throw some light upon the anatomy and systematic position of Stromatoporoids, though, as a matter of course, some points have necessarily been left doubtful or unsettled to a large extent, owing to the impossibility of obtaining access to many of the original specimens described by earlier observers.

Appended to the paper is the following summary of the author's conclusions:—"In this communication we have first given an epitome of the very diverse views held regarding *Stromatopora* up to the present time. We then treat of its fossil state, and show that, although the remains have been preserved in several mineral conditions, nevertheless the skeletal organization originally has been solely of a calcareous nature. We further contribute data bearing on the structural peculiarities, not only exteriorly and general, but as elucidated by microscopic research. It results that neither are the horizontal laminæ always porous, nor the vertical pillars usually tubular, as some have asserted. In one peculiar aberrant form, *Cannopora*, there are, in addition, large thick walled tubes penetrating the mass vertically, and undoubtedly belonging to the organism itself. In some forms, notably the genus *Stromatocerium*, there is a system of more or less perpendicular canals and lacunæ without walls; in others there is a paucity or even absence of such, though, in most, smaller and larger apertures open superficially. A further system of stellate obliquely-disposed canals exists, in many forms, both deeply and on the surface of the outer layers. While the typical *Stromatopora* are characterized by horizontal laminæ, supported by short upright pillars enclosing cuboid chambers or cells, some take on a vesicular character (*Clathrodictyon*), and others (*Pachystroma*) are destitute of pillars. Still other examples, essentially Stromatoporoid in aspect, &c., assume a more indefinite minute structure, with a tendency to a reticulate or trabecular formation. In certain forms (notably *Stylodictyon*) a columnar character obtains, the chambers showing a concentric arrangement round a dense but reticulate centre. Thus by their intimate structural peculiarities we attempt a tentative classification, wherein we can distinguish at least seven types of construction, which we rank provisionally as genera, and we describe *en passant* a few new and remarkable species.

In discussing the affinities of *Stromatopora* and its allies, we bring forward such evidence and argument as we believe is sufficient to warrant our excluding them in the meanwhile from alliance with the Nullipores, the Foraminifera, the Hexactinellid Sponges, the Polyzoa, the Corals, and certain fossil forms of uncertain affinities. As respects their Hydrozoal connection, we express ourselves with greater reticence, inasmuch as in both *Hydractinia* and *Millepora* not only are there certain superficial resemblances of considerable importance, but through the curious divergent form *Cannopora* structural peculiarities present themselves which possibly point to Hydrozoal relationships. Moreover, Mr. Carter's late very shrewd observations among the chitinous and calcareous *Hydractiniœ* necessarily render the object at issue open to further research before the decided negative can be affirmed. Mr. Moseley's* able investigations on the Hydrocorallinæ during the 'Challenger' Expedition, while they yield valuable hints, do not yet afford all that is desirable to unravel the knotty point. It is possible, though, that his future investigations of the ample material brought home may supply facts bearing more

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* 'Phil. Trans.,' 1876, vol. clxvi. pp. 91–129, pls. 8 and 9.

directly on the skeletal structure of the fossil Stromatoporoids. Lastly, respecting Sponge alliance, we are beset by obstacles, for neither do the Horny, Siliceous, nor Calcareous divisions, recent or fossil, so far as present knowledge extends, supply us with stable data whereon to assert identity. By reason of the nature of the skeletal basis the two former groups are necessarily excluded; while total absence of spicules in the Stromatoporæ, as widely understood, renders it impossible to class them unconditionally with the Calcareous order of the Sponges. But seeing that Hydrozoal construction, with its tubular zooidal cavities, tabulæ, &c., has not been shown to exist in the typical forms of the Stromatoporoids, and that neither in *Millepora* nor Hydractinia, &c., so far as we are aware, does such a system of intercommunicating passages and occasionally lacunæ without walls obtain, as exemplified in *Stromatocerium*, &c., we are constrained to adopt the parallel of the Siliceous Sponges with fused and adnate spicules, and assume the existence in times past of a Calcareous group of the class Spongida with a continuous skeleton composed of non-spicular granular calcareous matter. We are, however, by no means prejudiced, but hold ourselves open to conviction; for if hereafter it be demonstrated that the canal systems, &c., of the *Stromatoporæ* are not normal productions, as we at present believe them to be beyond any reasonable doubt, but 'branching canals bored by some low vegetable organism,' as Moseley (*l. c.* p. 116) avers is the case in *Millepora* and *Pocillopora*, &c., and, furthermore, that other structural Stromatoporoid peculiarities are present in undoubted members of the Hydrozoa, then we shall be willing to admit their alliance with the latter, though certainly they are aberrant types. With our present imperfect knowledge, and taking into account all the data for and against, we must at present regard them as a group *per se*, or, as we think justifiable on the positive and negative evidence, a new section of the Calcareous Sponges, for which we propose the term Stromatoporoidea."*

The Compound Microscope applied to the Examination of Electric Discharge in Gases.—In 'Nature' for September 19th † is figured and described the microscope devised by Drs. Warren De La Rue and Hugo W. Müller for this purpose. The body of the microscope is composed of two tubes (that next to the eye made of ebonite, for protection against accidental shocks) bent at an angle for convenience of observation, and at the angle is placed a revolving mirror which can be rotated by a multiplying wheel so as to make 1000 revolutions in a minute. The microscope is furnished with special mechanism to adjust the focus and the field of view.

Marine Excursion of the Birmingham Microscopical Society.—The second marine excursion took place on 19th to 27th July last, when twenty-eight members went to the island of Arran. A small steam yacht was chartered for the week; and as the result of the dredgings a beautiful series of specimens was taken, including *Luidia fragillisima*

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* The 'Journal of the Linnean Soc.,' vol. xiv. (Zool.), p. 187.

† 'Nature,' vol. xviii. p. 548.

and two or three Nudibranchs new to the locality, and many interesting forms of marine life, notably *Bipinnaria* and *Pluteus.* The towing-net, on an improved principle devised by Mr. Henry Allport, was used successfully.

Parasites of the Spongida.—Mr. H. J. Carter having examined all the specimens of sponges in the British Museum, together with those of Dr. Bowerbank, and with his own experience of living sponges, describes in the 'Annals of Nat. Hist.' * those parasites which have come under his observation. The description extends to sixteen pages, and is included under the following heads:—

CRUSTACEANS.

Small Amphipod Crustaceans about $\frac{1}{12}$ inch long not uncommonly nestle in the surface of some sponges in oval depressions, which in the absence of the animal may be taken for vents.

Crustaceans are commonly found in the cloaca, and half-way through its aperture in *Grantia ciliata* and *G. compressa*, especially towards the maturity of the *gastrula*, which they devour greedily.

CIRRIPEDES.

The Balanoid Cirripedes are perhaps the most common parasites of all, making use of every kind of sponge with the exception of the fleshy sponges (*Carnosa*), and the calcareous ones (*Calcarea*) becoming ultimately overgrown by the sponge, so as to form wartlike excrescences, with a hole in the summit for the projection of the cirri.

ACTINOZOA, OR POLYPS.

In all parts of the world sponges are more or less infested by polyps, chiefly on the surface, which may be single, double, concatenated or grouped, isolated or aggregated, sunk to the level of the surface of the sponge, which they may infest without scleroderma or with it *in* the scleroderma *on* the surface of the sponge or pendent from the scleroderma, and all belong to the Zoanthidæ = Palythoa, Lamour = Zoantha of De Blainville.

HYDROZOA, OR HYDROID POLYPS.

Extending into the deepest parts of the sponge, and in one instance entirely confined to the interior.

ALGOID PARASITES.—*Seaweeds.* It is not an uncommon occurrence in some parts of the world for a seaweed to become a pseudomorph of a sponge (to use a mineralogical term), in which the latter, like a "dissolving view," may be observed, though different specimens, to yield gradually to the former, so that at last the seaweed not only assumes the shape of the sponge generally, but that of the form and position of the vents and every other part of the sponge, saving the spicules or foreign bodies of a like nature, which thus are often the only remaining evidence of the *kind* of sponge that has been pseudomorphosed.

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* 'Ann. Nat. Hist.,' ser. v. vol. ii. p. 157.

An amorphous Red Alga (undescribed) parasitic in *Halichondria plumosa.*

Oscillatoria.

Scytonema.

Palmella spongiarum.

SAPROLEGNIEÆ.

Spongiophaga communis. A minute, short, nematoid filament, with a bulb at each end, which multiplying to an enormous extent, especially in the *Hirciniæ*, may become a pseudomorph of the sponge it attacks, so as to be mistaken for the sponge itself.

Saprolegnious Mycelium.

Under "FOREIGN OBJECTS," Mr. Carter refers to a little prism of calcite banded occasionally with yellow, brown, red, or amethystine colours, separately or more or less united in the same prism, which so frequently occurs in the Psammonemata derived from the disintegration of thin shreds like *Crenatula phasianoptera*, which are made up of similar prisms.

Under DENDRITES, he refers to the little colourless circular dendritic spots which appear on old kerataceous fibre, and whose structure is so minute, that under a $\frac{1}{4}$ inch with high ocular it does not appear satisfactorily. All that can at present be stated of them is that they are composed of branched filaments which radiate from a central point, but whether they are algoid or fungoid, or what their real nature is, future observation must determine.

A New Double Staining.—Dr. P. Schiefferdecker, of Rostock, describes in the 'Archiv f. Mik. Anat.,' vol. xv. p. 30, a process which he has used since 1876. He says:—" From my own experience, which has embraced almost all the tissues of animal structures, I can most warmly recommend it. I use the eosin, which Fischer introduced some time ago, and dahlia, methyl-violet, and anilin green. These have a very similar action, though sometimes they show definite specific differences.

The chief advantage of the new method is that in the compound organs the individual elements of the tissues or even different sections of the same tissue are very sharply distinguished by differences in colour which readily strike the eye, so that preparations for demonstration may be produced with really surprising beauty. The different colours harmonize with each other, the method is easily and quickly applied, and the tissue may be hardened directly in the alcoholic eosin solution. The durability of the preparations is also satisfactory, although under certain restrictions. They will only bear to be mounted in varnish, and must be kept in the dark, as the light affects the eosin. The method can be applied both to preparations which have been hardened in alcohol or in chromic acid, or even its salts. The tint of the colours is, however, often different in the two cases.

The procedure is as follows:—The eosin is used according to the directions of Fischer,* in an alcoholic solution, and 1 per cent. solutions in water are made of dahlia, methyl-violet, and aniline

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* 'Archiv f. Mikrosk. Anat.,' vol. xii. p. 349.

green.* The section is stained in a small dish containing alcohol, to which a few drops of eosin have been added. Time various; from half an hour to several hours; being left too long in the eosin is not detrimental. The section is then rinsed in water, whereby it loses some of the eosin, and is then laid in a watch-glass filled with a solution of one of the other colours, and allowed to remain some minutes till it is coloured very deeply, almost black. After the section has been again rinsed in water, it is placed in alcohol, which possesses the property in a very high degree of dissolving both the colours. This is the most critical part of the process, i. e. hitting the right moment when both the colours have been just sufficiently drawn out. It is a good plan to take the section out, and view it in oil of cloves under the microscope, and if found too deep, to replace it in the alcohol. In general it is better to remove the preparation when still too blue, as the eosin is drawn out somewhat quicker than the other colours. The oil of cloves, in which the preparation is put after the alcohol, does not affect the eosin, whilst it dissolves (in a somewhat different degree of intensity) the other colours. Any desired relation between the colours can thus be obtained. When the proper tint is reached, the oil of cloves is sucked out as completely as possible by blotting-paper (the best plan is to lay the paper on one side of the preparation on the stage, and place the stage slanting), then apply Canada balsam dissolved in chloroform for a covering. In this no further change takes place. If too much oil of cloves is left behind, a further extraction of the blue takes place, and the object is surrounded by a blue halo. This should therefore be carefully avoided.

As to the distribution of the colours over the different parts of the tissues, the blue (or the green) pigment stains principally the nuclei of the cells, and the eosin the cell-bodies, and attention may be drawn to the various shades of colour which appear in these latter, produced by the mixture of the red with the blue pigments, conditioned apparently by the mixture of the other cell-contents with the protoplasm, or by the changes produced in the protoplasm by age. With regard to the secretions of the cells, as far as these from their soft or firm consistency allow of being distinguished in microscopic sections, the former are generally stained more blue, the latter more red, often simply eosin red. Thus the contents of the goblet cells, whilst still contained in the cells or out of them, appear a deep blue, the interstitial substance of the hyaline cartilage light bluish, the cell-membrane eosin red, the elastic fibres brilliant red, the connective-tissue fibrillæ dark rose, the bone deep scarlet; a very peculiar and entirely characteristic colour is shown by the red blood-corpuscles, which are bright scarlet. In the blood of the lower vertebrate animals, which have nuclei in their blood-corpuscles, this colour forms a still greater contrast to the deep blue nucleus. The staining is so intense that sections of organs whose blood-vessels are still coloured with blood-corpuscles look as if injected, so strong is the contrast between the scarlet and the other tints.

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* Alcoholic solutions of these do not stain enough to be of use, therefore the eosin cannot be mixed with the other colours.

With regard to the particular organs, I have to remark as follows:—

(1) *The Skin.*—This is one of the objects which gives the best results. The different layers of the epidermis, and the whole epidermis contrasted with the cutis, show very prominently. In the cutis the dark, rose-coloured bundles of fibrillæ of the connective tissue appear remarkably distinct, so that their arrangement is easily recognized. Upon this rose-coloured substratum are seen with extraordinary distinctness the blue nuclei of the connective-tissue cells, the vessels with their scarlet contents and their musculature, and the sweat glands with their somewhat dark-blue stained cells, on the borders of which may be detected, on the exuding side, the fine red cuticula. Hairs and nails are also very beautiful.

(2) *The Muscular System.*—This is not very well adapted for the staining, as regards details. On the other hand, the tissue, as such, stands out very beautifully from other tissues. The smooth muscles, for instance, are distinguished in weak stainings from the surrounding connective tissue; they remain dark red, with a different tint to the connective-tissue bundles. The striated muscles have a somewhat darker tint.

(3) *Bones and Cartilage.*—The basic substance of the decalcified bones becomes deep scarlet, the cells more bluish. The method is best suited for the process of ossification. In this appears the peculiar phenomenon, that in the place where the cartilage cell nests lie the interstitial substance of the cartilage, which previously had a bluish red tint, acquires somewhat suddenly a deep blue colour, which would be the characteristic colour of the calcified cartilage. The basic substance of the bone, as above mentioned, appears stained a deep scarlet, and thus the superposed bone substance proper, down into the bone, is distinguished very clearly from the calcified cartilage. On the other hand, by this means the latter may be followed far into the bone, as every trace of it may be recognized, without anything else, by its blue staining. Thus it is possible to detect the cartilage-remains very plainly in the middle of the shaft of the bone, in a transverse section through the tibia of a new-born infant. The hyaline cartilage, with its bluish basic substance, and the red cells inserted in it, with a number of blue nuclei, is a most excellent object. The perichondrium is a deep red, and thus contrasts sharply with the cartilage. The division of the basic substance of the cartilage into different territories often appears very beautifully; the bounding parts are almost blue black. Elastic cartilage gives most excellent preparations; for instance, the transition portion from hyaline to elastic cartilage (e. g. cartilago arytænoidea). The elastic fibres are a lively red, and are thus well distinguished from the bright blue basic substance.

(4) *Nerve System.*—Transverse sections through the spinal cord show the coarser fibres very well, as the nerve-tubes, both medulla and axis-cylinder, are coloured red, whilst the neuroglia appears bluish red, with dark blue nuclei. The ganglion-cells are reddish, with a slight touch of blue, whilst their nuclei, in opposition to the nuclei of the other cells, appear somewhat redder than the cell-

substance. The nucleolus is generally a deep dark red. The double staining is specially recommended for the cerebellum, to make the granulated layers conspicuous. The Purkinje cells remain quite red, both nucleus as well as cell. I cannot recommend it, however, for the peripheral nerve system. In some few special cases it is applicable. The nerves in the bladder of the frog are very finely displayed. Methyl-violet (not the other colours) stains the fine nerves in the skin of the lamprey very beautifully.

(5) *The Alimentary Canal.*—We now come to a region in which the method answers very well—the glands; for, first, we are able to find constant differences in the staining of different glands; and secondly, in many cases, differences in the staining of the cells of the same glands, according to their condition. A very fine example of the first case is furnished by the aquiparous and muciparous glands in the root of the tongue. The first show a bright red protoplasm, with beautiful blue nuclei; the muciparous are stained with such an intense blue that the nucleus is often not visible. Both kinds of glands stand out also splendidly from the red muscular substratum. Examples of the second case are the gl. submaxill. and sublingualis. In the so-called state of rest, the cells are coloured uniformly blue, although not with the same intensity as the muciparous glands on the body of the tongue; the still darker blue nuclei lie, as is known, as though pressed flat close to one edge. In the so-called state of activity the cells are a granulated red colour, with round blue nuclei in the middle. The 'half-moons' are always red. The parotid has bright red cells, with blue nuclei. The pancreas is similar, only that the tint is rather bluer. One gland, the lachrymal—which, however, does not belong here—has most peculiar red cells.

The epithelium of the mouth, tongue, and œsophagus separate themselves, on being stained, into a superior and inferior layer, and the epithelium and the glands of the stomach and intestines are excellently adapted for the staining."

The effects of the staining on (6) Liver, (7) Organs of respiration, (8) Urinary organs, (9 and 10) Male and female sexual organs, (11) Blood-vessels, (12) Lymphatic glands, &c., and (13) Organs of sense, are detailed in a similar manner, but must be omitted here for want of space.

The Ordinary Microscope as a Polariscope for Convergent Light.—In reference to Professor A. de Lesaulx's suggestions on this subject (see p. 207), M. Bertrand claims to be an independent discoverer with the Professor of the advantages to be derived from adding two achromatic lenses of short focus above the lower Nicol. He places, however, a third achromatic lens of about 3½ centim. focus above the posterior lens of the objective, at a distance a little greater than the focus, and capable of being slightly moved nearer or farther from the objective according to the power used. It should also be able to be removed easily from the microscope, so as to allow of the object being viewed in the first instance by parallel light.

New Aerobic Vibrion.—M. H. Toussaint has recently described a vibrion which he found in a rabbit inoculated with the blood of a horse which had died rapidly of malignant pustular fever. The blood was received sixty hours after the death of the horse, and its state of preservation was such as to enable the author to affirm that it had never contained bacteria. A rabbit was at once inoculated by two punctures in the ears, which died in twenty-four hours afterwards, no bacteria being anywhere found. A second rabbit was then inoculated, which died in thirteen to fourteen hours, and it was in the latter that the new vibrion was discovered. Fifty-four other animals were subsequently inoculated, with the same results. When the blood was examined under the microscope with a power of 500 to 800 diameters, a great number of extremely small vibrions were seen, spherical or slightly oval, of very little refracting power (which makes it difficult to distinguish them in the coloured serum), single or in pairs, never three in a chain. Their dimensions vary little, being ·0004 mm. in thickness, and ·0005 mm. to ·001 mm. long, the latter dimension attained only by vibrions which have just separated. Their only movements are feeble and slow, which clearly distinguishes them from Brownian movements. Whilst very numerous in the blood (five to ten to a globule), they exist in immense quantities in the lymphatic ganglions, and swarm in the œdema at the point inoculated. They are found in all the tissues outside the vessels, and in all the fluids—the humours of the eye, the serous fluids, and the urine. When the epiploon is examined with a strong power, they are clearly distinguished in the interior of the vessels in the form of a mass of regular granulations which often occupy the whole breadth of the capillaries, and stand out in relief at their optic margin.

All the fluids can be inoculated in the same way as the blood—inoculation of the aqueous humour, the urine, and the chyme kills the animals in twelve hours. The disease is not only contagious by direct inoculation, it is equally so by the alimentary canal, and perhaps also by the respiratory passages. Three rabbits died in eighteen to twenty-four hours after having eaten oats soaked in the infected blood. Excrement powdered and mixed with the food killed two rabbits out of six who had such food on one occasion. Two other vigorous rabbits died the next day, after having passed one night with two inoculated ones, and three adult rabbits in adjoining boxes died in the same way without any direct contact.

M. Toussaint cultivated the vibrions by M. Pasteur's method, and under the microscope in the gas and warm chamber of M. Ranvier, and was able to establish that in two hours and a half a single one had produced twenty-two. The multiplication took place by scission as soon as the vibrion had doubled in breadth. Filaments analogous to those of the bacteria were never formed. They multiplied more rapidly at the sides next to the air-groove than in the middle of the preparation.

Contact with air or pure oxygen in a moist chamber for twenty-four hours preserved a layer of blood of $\frac{1}{5}$ mm. in thickness in full activity. In tubes free of air and sealed, the blood lost its activity at the end of ten days. Putrefaction destroys the vibrion, but much more slowly than the bacteria.

When mixed in the culture liquids the bacteria and the new vibrions develop side by side. When animals are inoculated with them (taking care to have only a very small quantity of the latter) the two parasites are developed simultaneously, and on a microscopic examination are found associated in the blood. But on the second inoculation the bacteria are still localized at the point of inoculation, whilst death has already taken place in consequence of the much more active multiplication of the vibrions.

In a foot-note the author adds that he has found Ranvier's warm chamber extremely convenient for studying all the lower beings, and particularly bacteria. Their elongation can be followed minute by minute, and the transformation into spores as well as the elongation of the spores to re-form the bacteria. He was thus able recently to determine that the bacteria cultivated in certain liquids, especially in the serum of the blood of the dog, give sometimes true sporangia, globular or in "calabashes" filled with spores.*

"*The Projection of Microscope Photographs.*"—Dr. J. C. Draper, Professor of Natural History in the College of the City of New York, contributes an article under this heading to the 'American Journal of Science and Arts.' In the lanterns that are constructed for the projection of photographic or other images on a screen, the support or stage on which the photographic slide is placed is close to and at an invariable distance from the condensing lens. So long as the objects to be projected are nearly equal in size to the diameter of the condenser, this is the only adjustment that can be made to illuminate the whole surface of the object, but when the diameter of the field occupied by the object is only one-half or one-quarter of the diameter of the condensing lens, the brilliancy of the result obtained upon the screen may be greatly increased by removing the supporting stage or object carrier to a greater distance from the condenser, so that a convergent beam of light may fall on the object to be projected. To accomplish this I have constructed the following form of lantern.

In the figure, *a* is a zirconia light mounted on an adjustable base,† which may be used with a condensing lens of very short focus, since the zirconia is not burrowed into cavities where the oxyhydrogen flame impinges, as happens with lime cylinders, and causes the flame to be reflected on the condensing lens, and thereby destroys it. In the jet employed, the gases are mixed just before they are ignited. *b*, *b* is a short-focus condensing lens; *c*, the stage or support carrying the photographic or other design to be projected; *d*, the projection lens formed of three sets of lenses, and giving a perfectly flat rectilinear field; *a*, *c*, *d* are mounted on a base board *e*, *f*, to the end of which the lantern box *a*, *b* is attached, and which is freely opened above and below to permit perfect ventilation. The base carries lateral grooves in which *a*, *c*, *d* slide, allowing them to be placed at varying distances from *b*, and fixed by suitable binding screws; *c* and *d* are also connected together by a rod *r*, carrying an adjustment screw at *r*, by

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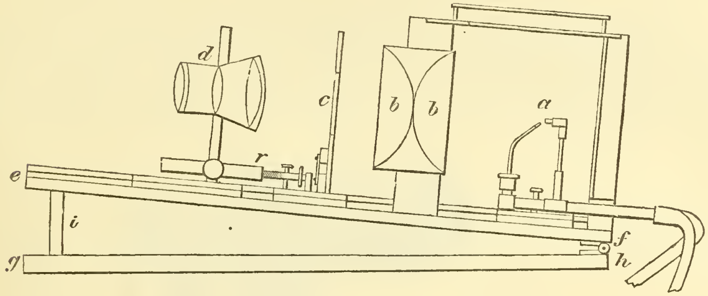
* 'Comptes Rendus,' vol. lxxxvii. p. 69.

† See 'American Journal of Science and Arts,' Sept. 1877, p. 208.

which the change of distance between *a* and *c*, required in giving the correct focus, may be obtained. The base *e*, *f* is attached to a second or under base *g*, *h* by a hinge at *h*, which allows the end *e* of the movable base *e*, *f* to be raised to any required angle, at which it may be maintained by the block at *i*. So convenient and compact is this lantern, that it may easily be stowed away in a small trunk.

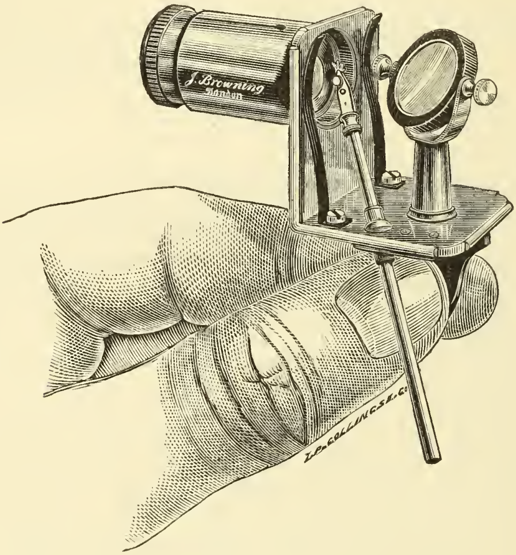


When a series of objects of different sizes is to be projected, as is the case with microscopic photographs taken under the same adjustments, it is, as we have said, a great gain in the projection of small objects if the circle of light used for illumination is reduced, and at the same time increased in brilliancy. This is accomplished in the above arrangement as rapidly as can be desired by removing *d*, *c* together along the slide of the base *e*, *f* to a sufficient distance from the face of the condenser *h* to allow the convergent rays of the latter just to cover a circle which will include the object to be projected. The greater intensity of the illumination thus obtained renders the definition of fine markings or other peculiarities on small objects as clearly visible at considerable distances as are the coarser markings on large objects under a weaker light.

In closing this brief communication, I desire to add that I made photographs of *Frustulia Saxonica* under a power of 7000 diameters. The photographs in question were made in the City College building, by a $\frac{1}{20}$-inch immersion Beck lens. The light was from the sun, reflected by a heliostat through ammonio-sulphate of copper solution and condensed on the object at an angle of 30° to 40°. The photograph in question was direct, by which I mean that there was no intermediate or secondary enlargement of a first photograph. With this photograph and the lantern described I have shown *Frustulia Saxonica* magnified more than half a million diameters, a result which must be seen to be appreciated.

Cleaning Slides and Cover-glasses.—Mr. C. E. Hanaman, of the Troy (U.S.) Scientific Association, recommends as being as efficacious as the nitric acid bath, and wholly free from its disagreeable odours, a cold saturated solution of bichromate of potash in water, to which about one-eighth of its bulk of strong sulphuric acid is added, the mixture being made in a porcelain or thin glass vessel, as the heat evolved would be likely to break a bottle, and the vessel placed outside the window until cool, when no more injurious vapour will be given off. A gross or two of slides may be cleaned in an incredibly short time by sliding them one by one into a vessel containing the liquid, tilting the vessel about a few moments to cause the liquid to flow through the mass, then pouring it off, and placing the vessel under the stream of a tap. The solution is well known to photographers.*

Miniature Microscope.—A diminutive instrument, small enough to be carried in the waistcoat pocket, and available for viewing objects mounted on the ordinary slides, has just been brought out by Mr. John Browning. It is made in nickel silver, and has two achromatic powers, magnifying respectively 15 and 35 diameters (the latter with a Lieberkuhn), as well as a movable mirror and forceps. The accompanying woodcut of the instrument is full size.



Notommata Werneckii—a Parasite of Vaucheria.—Besides the well-known *Notommata parasita* which inhabits *Volvox globator*, there is another species of the genus living in an Alga which has hitherto been little observed. M. Balbiani having obtained some specimens from M. Cornu, has made an extended investigation, not only of the animal, but of the so-called "galls" of the *Vaucheria* which they inhabit. The article appears in the 'Annales des Sciences Naturelles,' but, though published so long ago as 20th March, the plate has not yet (October 15) reached London. When this is done it is proposed

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* 'American Naturalist,' vol. xii. p. 573.

to print here a translation of the article *in extenso* with the plates, but meantime the following summary of M. Balbiani's observations will show the general conclusions at which he arrived.

In the existence of *N. Werneckii* there are two periods, the one of freedom, the other of parasitism in the tubes of *Vaucheria*. In each of these two phases of its existence it assumes a very different form. In the first it is elongated, vermiform, and divided exteriorly into very distinct segments. In the second, when it attains the age of maturity, it is dilated, very contractile, and without any trace of segmentation.

To these exterior changes correspond important modifications in the internal organs, characterized particularly by the enormous development of the ovary and the atrophy of the salivary and gastric glands.

As with many other Rotatoria, it lays two kinds of eggs, called summer eggs and winter eggs, which are distinguished from one another by their structure no less than their mode of development.

The same female may produce either summer or winter eggs exclusively, or the two kinds mixed in the same gall.

The winter eggs are produced as early as the spring; their laying commences later and is prolonged longer than that of the summer eggs — the latter are developed immediately, whilst the former hybernate, and are only hatched in the following year.

Males were not observed, and on the other hand spermatozooids were never found in the females; whence it is concluded that the winter eggs, like the summer eggs, develope without previous fecundation.

The galls of *Vaucheria*, in which the animal lives and is reproduced, are due to a hypertrophy of the branches of the plant which bear the organs of fructification. They differ from the galls, properly so-called, of the higher plants, in that they are pre-existing parts, which have simply undergone an increase of volume under the action of the parasite. This exaggeration of the vegetative functions is also often manifested by the formation of adventitious branches on different points of the surface of the gall.

The exit of the young born in the galls, and their re-entry into the tubes of the *Vaucheria* to form new galls, is effected by openings which are produced spontaneously at the summit of the adventitious branches. They also sometimes make use, for the same object, of the male organ of reproduction, which persists at the base of the capsule in the form of a tube open at its two extremities.

"Bismarck Brown" as a Staining Material.—In the 'Archiv für Mik. Anat.,' vol. xv. part 2, is an article by Dr. C. Weigert on the superiority of this pigment over those hitherto used. The requirements in a good staining matter are, he says:—(1) It must stain with perfect certainty, so that nothing is left to accidental circumstances or the ability of the histologist. This condition is not fulfilled by carmine, picrocarmine, or eosin. (2) The stain must take quickly. In this respect, too, the two first-named pigments are defective. (3) Overstaining must not take place too readily, or must be capable of cor-

rection without having recourse to very different materials, as e. g. strong acetic acid. (4) On the other hand, a proper time must be allowed for the necessary operation of washing, so that the colour does not disappear if the washing is prolonged somewhat. The aniline colours hitherto employed do not permit this. (5) The preparations must be capable of being viewed and preserved in a medium of small refractive power. This is not possible in the case of hæmatoxylin staining, and where aniline colours are used. (6) The stain must be a fixed colour. All these conditions are satisfied in the pigment which is called Bismarck brown. The application of it is very simple. A concentrated solution of it in water or weak alcohol is used. To obtain the former quickly, the pigment must be boiled in distilled water, which serves at the same time to prevent the formation of the white film to which it is subject. The solution is then filtered (the filtration requires to be repeated from time to time). Sections of alcohol or chromic acid preparations are stained immediately on being put into such a solution, which is of a dark brown colour; if the solution is weaker, but still strong, the sections become deeply stained in a few minutes. The differentiation of the staining is effected in a few minutes by washing in absolute alcohol, and then the preparations (cleared by oil of cloves, &c.), may either be kept in Canada balsam, or put up direct in glycerine. In the latter case, care must be paid to the washing in alcohol, and it is as well to put the preparation previously in distilled water again. No harm at all is done if the section is left a day or two in the staining fluid, or allowed to lie for hours in alcohol or days in oil of cloves, provided the stain is not too weak in the first instance.

The nuclei are stained brown by it, and, as with all good stains, more or less dark according to their size. Many protoplasms and connective tissues stain a more or less light yellow. Amyloid is not plainly differentiated, but plasma-cells and many bacterian forms are, which resist hæmatoxylin and carmine stains. Double staining, &c., can be applied, of course, as well as with other pigments for nucleus staining. From an æsthetic point of view, the colour will not perhaps give satisfaction. This, however, is a matter of taste, and the tint has the advantage that preparations thus stained can be photographed. Our blue and red stains are badly adapted for photographing.

Thin Covering Glass.—A complaint is made in the 'Zeitsch. f. Mikroskopie' that the covering glass supplied from England in recent years is of bad quality, not only being of excessive thickness, but containing bubbles and a number of microscopic points which cannot be removed by any chemical means, so that a great part is unsuitable for any delicate investigations. Complaints addressed to the manufacturers have, it is said, met with no success.

Improved Form of Frog-plate.—With the common brass frog-plate generally used it is almost impossible, after the frog has been properly secured, to move the plate under the clips which in the cheaper microscopes serve to retain the object in place on the stage. A very simple addition, however, serves to remedy this defect, and makes the most convenient frog-plate we have ever used. A plain under-plate is riveted to the ordinary notched (upper) plate at one end with a strip between them, which holds them a little more than an eighth of an inch apart. The lower plate (which has a hole which corresponds with that in the upper one) passes under the clips of the stage, which retain it securely, but allow proper freedom of motion.*

Variation in Spongilla fluviatilis.—Mr. J. G. Waller details, in No. 37 of the 'Quekett Club Journal,' the result of examinations which he has made on various specimens of Spongilla, principally from different parts of the Thames. He shows that it is subject to considerable variation, but from the easy manner in which the changes seem to pass through a series of gradations to a complete development of parts, and notwithstanding the remarkable differences between the two extremes (the smooth spicule of the type yielding place to the spinous one and becoming practically obsolete), he considers that, undoubtedly, *S. Meyeni* and *S. Parfitti* should be treated as varieties only, and not as distinct species. Mr. Waller considers that *S. fluviatilis* may be divided into two natural divisions, one having the spicule smooth and the other spinous.

Borax in Vegetable Physiology.—If we immerse in a cold aqueous solution of borax (from 5 to 6 per cent.) vegetable organs containing different colouring matters, the red, blue, purple, or violet liquid matters diffuse themselves rapidly in the solution, whilst the green pigment of the grains of chlorophyll is not diffused. We can in this manner show the presence of chlorophyll in plants in which it is completely masked by other colouring matters, for example, in the red variety of *Atriplex hortensis*, in *Simodurum abortivum*, in certain red and yellow Algæ, &c. A little unicellular Alga, which produces blood-coloured stains on damp vaults, the *Porphyridium cruentum*, Naeg., has been placed by Rabenhorst among the *Phodophyceæ*, Algæ which are distinguished from others by the absence of chlorophyll, and by the presence of a generally red colouring matter. But it is sufficient to immerse this little Alga for a few hours only in a solution of borax, in order to see the whole of the red matter disappear; the plant then becomes completely green under the influence of the true finely-divided chlorophyll. †

The Vernier applied to the Microscope.—American opticians have recently applied the vernier to the body of the microscope (in which they are being followed by English makers), and some controversy has taken place in the States as to who was the "first and true inventor." *A propos* of this controversy M. Bauwens, the Treasurer of the Belgian Society of Microscopy, communicated a paper to the Society on the subject, from which the following extracts are made:—

"It is about ten years since I applied the vernier to my Jackson-Lister instrument, the scale being applied to the movable body, and

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* 'American Journal of Microscopy,' vol. iii. p. 158.

† M. Schnetzler, in 'Comptes Rendus,' vol. lxxxvii. p. 381.

the vernier to the support in which the body slides. I can affirm that it is of real utility—

1. When one desires to know the 'frontal distance' (that is the distance between the anterior surface of the front lens and the point where the object ought to be placed) of each of the combinations of eye-pieces and objectives which are used.

2. To measure easily and rapidly the thickness of the covering glass—a very important matter in many circumstances.

3. To find the thickness of the objects examined, &c., and for many other cases, too long to be enumerated.

The vernier which I use is composed of two distinct pieces, sliding one against the other; the one forming the scale is divided into millimetres; the other is the vernier, that is, a piece on which a length of nineteen millimetres is divided into twenty equal parts. As an example, suppose we want to know the thickness of a covering glass. Make a line in ink on one of the faces of the glass, and a line on the other side of it. Find under the microscope the visual point of one of the sides, and note the reading of the scale. In the same way take the visual point of the other line, and the difference between the two measures is the thickness."

M. Bauwens also describes the way in which he applied a second vernier and scale to the draw-tube and body, so as to determine the exact distance between the eye-piece and objective.

Micro-photograph.—Mr. Langenheim, of the United States, has photographed the Lord's Prayer on the ten-thousandth of a square inch, and "so fine that it will bear inspection with a good $\frac{1}{6}$th and B eye-piece."

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On the Structure and Development of the Vertebrate Ovary. By F. M. Balfour, M.A., Fellow of Trinity College, Cambridge. (With 3 plates.)

The Reproduction of Lichens and the Sexuality of the Ascomycetes. By Sidney H. Vines, M.A., Christ's College, Cambridge. (With a plate.)

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Recent Observations on *Botrydium granulatum.*

Motility of the Spermatozoids of Limulus.

The Early Developmental Changes in the Reptilian Ovum.

Recent Researches on Bacteria.

The Development of Calcareous Sponges.

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On the *Nauplius* and Pupa Stage of Suctoria. By Professor Alfred Giard.

Studies on Fossil Sponges. II. Lithistidæ. By Karl Alfred Zittel. (*Continuation.*) (With a plate.)

On the Mode of Development of the Tentacles in the Genus *Hydra.* By M. C. Mereschkowsky. (With a plate.)

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On Anthracnose—a New [fungus] Disease of the Vine. By Dr. Maxime Cornu. (Translated from the 'Bulletin' of the Botanical Society of France.)

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The Birth of a Rotifer. By John Davis. (With 2 woodcuts.)

Microscopy.—An Improved Wax Cell.—Quekett Microscopical Club (Thirteenth Annual Meeting).—A Theoretical Limit to the Apertures of Microscopical Objectives (Note of Professor Stokes' paper).

For October :—

Microscopy.—"New Forms of Animal Life!!"—Highbury Microscopical Society.—Measuring with the Microscope (Burch's Micrometer).—The Miniature Microscope Lamp.

NATURE :—

August 8:—Letter from H. Darwin: The application of the Peaucellier Cell to an arrangement to make two points—one on each side of a lens—move in such a way as always to remain at conjugate foci. (With a woodcut.) Biological Note: The Primary Germ-Layers and the Origin of the Male and Female Reproductive Elements (a Summary of J. Ciamician's article (on the Hydroida), in 'Zeitsch. f. wiss. Zool.').—The Influence of Light upon Bioplasm. By A. Downes, M.D., and J. P. Blunt, M.A. August 22:—Notes on the discussion in the French Academy on the late Claude Bernard's experiments on Alcoholic Fermentation, and on the Second Marine Excursion of the Birmingham Natural History and Microscopical Society. September 5:—Note on Objects exhibited at the Society's Meeting on Tuesday last, and on Herr Muntz's Experiments on Alcoholic Fermentation. September 12:—The Origin and Distribution of Organic Colour. By W. S. Kent. September 19:—Electric Discharge in Gases. II. By Drs. Warren De la Rue and H. W. Müller. (With a woodcut of a Compound Microscope with revolving Mirror.)

POPULAR SCIENCE REVIEW for October :—

Notes on the Ophiurans, or the Sand and Brittle Stars. By Professor P. Martin Duncan, M.B. (Lond.), F.R.S., &c. (With a plate.)

On the Radiolaria as an Order of the Protozoa (*conclusion*). By Surgeon-Major G. C. Wallich, M.D., &c.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY, Vol. CLXIX., Part 1 :—

On the Structure and Development of Vascular Dentine. By Charles S. Tomes, M.A. (With 3 plates.)

Experimental Researches on the Electric Discharge with the Chloride of Silver Battery. Part I. By W. De la Rue, M.A., D.C.L., F.R.S., and H. W. Müller, Ph.D., F.R.S. (With a woodcut of Compound Microscope with revolving Mirror.)

PROCEEDINGS OF THE ROYAL SOCIETY, Vol. XXVII., No. 187 :—

On the Development of the Parasitic Isopoda. By J. F. Bullar, B.A., Trin. Coll., Cambridge.

On the Life-History of a Minute Septic Organism: with an account of Experiments made to determine its thermal Death Point. By the Rev. W. H. Dallinger. (With 2 plates.)

Note on the Minute Anatomy of the Thymus. By Herbert Watney, M.A., M.D., Cantab.

No. 188:—

Contributions to the Anatomy of the Central Nervous System in Vertebrate Animals. Part I. *Ichthyopsida.* Sec. 1. *Pisces.* Sub-sec. 1. *Teleostei.* By Alfred Sanders, M.R.C.S.

On the Existence of a Rudimentary Head-Kidney in the Embryo Chick. By F. M. Balfour, M.A., Fellow of Trin. Coll., Cambridge, and Adam Sedgwick, B.A., Scholar of Trin. Coll., Cambridge.

On *Astrophiura permira*, an Echinoderm form intermediate between Ophiuroidea and Asteroidea. By W. Percy Sladen, F.L.S., F.G.S.

The Life-History of *Bacterium termo* and *Micrococcus*, with further observations on *Bacillus.* By J. Cossar Ewart, M.D. Edin. (With a plate.)

On the Life-History of *Spirillum.* By Patrick Geddes and J. Cossar Ewart, M.D. Edin., University College, London. (With 2 plates.)

On an Easy and at the same time Accurate Method of determining the Ratio of the Dispersions of Glasses intended for Objectives. By Professor G. G. Stokes, M.A., Sec. R.S.

No. 189:—

Observations on Arctic Sea-water and Ice. By Staff Surgeon E. L. Moss, M.D., R.N., late of H.M.S. 'Alert.'

JOURNAL OF THE LINNEAN SOCIETY (ZOOLOGY), Vol. XIV., No. 75 (issued 31st August):—

On the Minute Structure of *Stromatopora* and its Allies. By Professor H. Alleyne Nicholson, F.L.S., &c., and Dr. J. Murie, F.L.S., &c. (With 4 plates and 5 woodcuts.)

Observations on Ants, Bees, and Wasps.—Part V. Ants. By Sir John Lubbock, Bart., M.P., F.R.S., F.L.S., D.C.L., Vice-Chancellor of the University of London. (With 5 woodcuts.)

On the Development of *Filaria sanguinis hominis.* By Patrick Manson, M.D. (Communicated by Dr. Cobbold, F.R.S., F.L.S.)

CROYDON MICROSCOPICAL AND NATURAL HISTORY CLUB—EIGHTH REPORT AND ABSTRACT OF PROCEEDINGS:—

The Micro-spectroscope. By Thomas Palmer, F.R.M.S., B.Sc.—On Bees. By Dr. Beeby.—Hints on Microscopy to Beginners. By Dr. H. J. Strong.

Proceedings at Eighth Annual Meeting, Abstract of Proceedings for 1877, &c.

AMERICAN JOURNAL OF MICROSCOPY AND POPULAR SCIENCE for July:—

Trichinosis. Paper read before the Calhoun County Medical Society, by Dr. D. C. Hauxhurst.

The Presence of Elastic Fibres in Phthisical Expectoration. (From 'Cincinnati Medical News.')

The New "Oil-Immersion" Object-glass constructed by Carl Zeiss, of Jena (Mr. Dallinger's letter to 'Nature' of 16th May.)

Canada Balsam Microscopes. By A. Y. Moore.

On Preparing and Mounting Leaves and other parts of Plants to show the Crystals in situ. By W. H. Hammond. (From 'Science-Gossip' for June.)

How to make an Aquarium of Microscopic Objects.

Wide-angled Objectives for purposes of Natural History (letter from Mr. Dallinger to Mr. Stodder, of 22nd June, 1876).

A Collecting Microscope. By A. Y. Moore. (With a woodcut.)

New Binocular Eye-piece by Hartnack and Prazmowski. (From 'Journal de Micrographie.')

A Roundabout Walk to Church.

A New Form of Frog-Plate. (With a woodcut.)

Dr. Carpenter on Angular Aperture. By W. G. Lapham. (*Concluded*)

Porphyry. Paper read by M. Atwood, F.G.S., before the San Francisco Microscopical Society, May 16, 1878.

The American Quarterly Microscopical Journal.

The National Microscopical Congress.

Correspondence.—C. Stodder: Angular Aperture again.—L. M. Willis, M.D.: Oil-Immersion Objectives.—A. Y. Moore: Oiling the Microscope.

Transactions of the San Francisco Microscopical Society of 6th June, and account of the Sixth Annual Reception of 23rd May.

For August:—

On the Life-History of a Minute Septic Organism: with an account of Experiments made to determine its thermal Death Point. By Rev. W. H. Dallinger. (With 2 plates.) (From 'Proc. Roy. Soc.,' No. 187.)

Microscopical Research. ('Scientific Opinion,' June 2, 1869.)

Notes on Century III. of the "Species Typicæ Diatomacearum," by Professor H. L. Smith, Geneva, N.Y.

A Microscopical Cabinet.

Balsam Mounts. By F. M. Hamlin, M.D.

Collection of Canada Balsam. ('Trans. Am. Pharmaceutical Association.')

The American Society of Microscopy.

Transactions of the New Jersey Microscopical Society of 27th May; San Francisco Microscopical Society of 20th June and 1st August; and of the State Microscopical Society of Illinois of 22nd August.

A Remarkable Photograph (Lord's Prayer in $\frac{1}{10000}$ inch).

For September:—

Proceedings of the National Microscopical Congress, held at Indianapolis, August 14–17, 1878.

Angular Aperture. By Professor Abbe, of Jena.

Paste Eels. (From 'Young Scientist.')

Pond and Stream. By H. Watson.

How to Silver a Mirror. By F. L. James, Ph.D., M.D. (With 2 woodcuts.)

A Story of Science. (From 'Fun.')

Correspondence.—A Card from Mr. Gundlach. Mr. Schramm's Reply.

Transactions of the San Francisco Microscopical Society of 15th August.

Exchanges.

American Journal of Science and Arts for September:—

On the Animal of *Millepora alcicornis.* By W. N. Rice. (With 20 figures.)

American Naturalist for August:—

Microscopy.—Proceedings of Meetings on 6th May and 3rd June, of Microscopical Section of Troy Scientific Association, containing Rev. A. B. Hervey on the Classification of Algæ by means of Fructification, and Mr. C. E. Hanaman on Cleaning and Handling Slides and Cover-glasses.—New Microscopical Journals. —New American Objectives.—Minerals for the Microscope.

For September:—

Review of Flögel on the Structure of the Brain in different Orders of Insects; and Barrois' Embryology of Bryozoa. (With 10 woodcuts.)

Journal de Micrographie for August:—

Summary:—The Microscope applied to Mineralogy, and Mr. M. Atwood's paper on the Preparation of Microscopical Sections of Rocks, read before the San Francisco Microscopical Society.—Notices of the Contents of Foreign Journals, &c.

The Lymphatic Hearts (*continuation*). By Professor Ranvier.

Observations on the Termination of the Motor Nerves of the Striated Muscles of the Torpedoes and the Rays (*conclusion*). By Professor Ciaccio.

Preliminary Note on the Development of the Blood and the Vessels (*continuation*). By Drs. V. Brigidi and Al. Tafani.

On the Isogenic Groups of the Cellular Elements of Cartilage. By Professor J. Renaut. (From 'Comptes Rendus.')

On the "Gum Disease" of the Lemon Trees (*Fusisporium limoni*) (*continuation*). By G. Briosi.

A New Field for the Microscopist (continuation of the translation of Mr. Kent's paper).

Microscopical Society of Dunkirk (U.S.).

Paraboloid Illuminator of Dr. Edmunds.

Microscopic Technics. (Extract from Dr. J. Pelletan's 'Practical Manual of Histology').

&c. &c. &c.

ANNALES DES SCIENCES NATURELLES (BOTANY), Sixth Series, Vol. V. No. 6 (issued in August):—

Investigations on the Secretory Canals of the Fruit of the Umbelliferæ. By M. R. Moynier de Villepoix. (With 2 plates.)

Vol. VI., Nos. 1 and 2 (issued in August):—

Researches on the Terminal Growth of the Root in the Phanerogams. By M. Ch. Flahault. (With 8 plates.)

Vol. VI., Nos. 3 and 4 (issued in September):—

Researches on the Terminal Growth of the Root in the Phanerogams (*conclusion*). By M. Ch. Flahault.

Development of the Embryo-sac of the Angiospermous Phanerogams. By M. Julien Vesque.

BULLETIN DE LA SOCIÉTÉ BELGE DE MICROSCOPIE, Vol. IV., No. 10:—

A Case of Parasitism observed on a Diatom. By M. Guimard. (With a woodcut.)

Ross's Patent Stand. By Dr. Henri Van Heurck. (With a plate.)

Analytical and Critical Review—of 'Proceedings of the Boston Society of Natural History,' 'Journal of the Royal Microscopical Society' of London, and 'Journal de Micrographie' of Dr. J. Pelletan, with "Contribution to the History of *Ligula*" and "Observations on the Rotatoria and the Infusoria" extracted from the latter journal.

Proceedings of the Meeting of the Society on 25th July.

No. 11:—

Further Note on the Ordinary Microscope as a Polariscope for Convergent Light, and an Apparatus for measuring the Distance of the Poles in the Interference Image. By Professor A. de Lasaulx. (With a plate.)

A New Field for the Microscopist (the first part of a translation of Mr. W. S. Kent's article in the 'Popular Science Review').

Proceedings of the Meeting of the Society on 29th August.

ARCHIV FÜR MIKROSKOPISCHE ANATOMIE, Vol. XV., Part 2 (issued in June):—

Contributions to the Development-History of the Vertebrates. By Dr. A. Goette, Professor at Strassburg. III. On the Development of the Central Nervous System of the Teleostei. (With 4 plates.)

Researches on the Stellated Cells of the Tubules of the Testes and other Glands. By Dr. B. Afanassiew, of St. Petersburg. (With a plate.)

On the Connexion of the Anterior Eye Chamber with the Anterior Ciliary Veins. By F. Heisrath.

On the Blood-vessels of the Eye of the Cephalopods. By Dr. Jos. Schöbl, of Prague. (With 2 plates.)

On the Blood-cells of the Acephalæ, and Observations on their Blood-course. By W. Flemming. (With a plate.)

Note on the Injection of the Invertebrates. By W. Flemming.

On the Theory of Peristalsis. By Th. W. Engelmann, of Utrecht.

"Bismarck Brown" as a Colouring Substance. By Dr. C. Weigert, First Assistant at Pathological Institute at Leipsic.

Vol. XV., Part 3 (issued 23rd August):—

The Genesis of the Spermatic Bodies. By V. la Valette St. George. Fifth communication. (With 5 plates.)

Contributions to the Comparative Morphology of the Skeletal System of the Vertebrates. By Dr. A. Goette, Professor at Strassburg. II. The Vertebral Column and its Appendages. (With a plate.)

The Acoustic Apparatus of the Organs of Hearing of the Heteropods. By C. Claus, of Vienna. (With a plate.)

On *Tetrapteron* (*Tetraplatia*) *volitans*. By C. Claus. (With a plate.)

The Architecture of imperfectly divided Teeth-roots. By Professor Dr. Chr. Aeby, of Bern. (With a plate and a woodcut.)

The Histological Relations of Fossil Bone and Tooth Tissue. By Professor Dr. Chr. Aeby, of Bern. (With a plate.)

The Development of the Egg in Batrachians and Bone Fishes. By N. Kolessnikow, of St. Petersburg. (With a plate.)

The Taste Cells of the Duck. By Fr. Merkel, of Rostock. (With a plate.)

Supplement to the article "The Vertebral Column and its Appendages": 1. The Cyclostomata. By Dr. Götte.

ZEITSCHRIFT FÜR MIKROSKOPIE for May:—

The Development and present Position of Microscopy in Germany (*continuation*). By Dr. E. Kaiser.

Contribution on Plant Crystals, particularly on the forms of Quadratic Oxalate of Lime. By Dr. G. Holzner. (With a plate.)

The "Plastides" of the Lower Plants.

The Rivet Microtome.

Minor Communications.—Orth's 'Course of Histology.'—Wenzel's 'Atlas of Histology.'—Programme of Fifty-first Meeting of German Naturalists and Medical Men at Cassel.

SIEBOLD AND KÖLLIKER'S ZEITSCHRIFT FÜR WISSENSCHAFTLICHE ZOOLOGIE, Vol. XXXI., Part 1 (issued 30th July):—

On the Siphonophora of Deep Water. By Th. Studer. (With 3 plates.)

Supplement to "Contributions on the Post-embryonal Formation of the Limbs in Insects." By H. Dewitz.

Contributions to the Morphology of the Oxytrichidæ. By V. Sterki. (With a plate.)

Contributions to the Knowledge of the *Tomopteridæ*. By F. Vejdovsky. (With 2 plates.)

Contributions to the Knowledge of the Natural History of the Caprellæ. By A. Gamroth. (With 3 plates.)

Part 2:—

Contributions to the Knowledge of the Iulidæ. By E. Voges. (With 3 plates.)

On the Formation of the Blastoderm and the Mesoblasts in Insects. By N. Bobretsky. (With a plate.)

Researches on the Structure and Development of Sponges. 5th Part. The Metamorphosis of *Sycandra raphanus*. By F. E. Schultze. (With 2 plates.)

PROCEEDINGS OF THE SOCIETY.

Meeting of 9th October, 1878, at King's College, Strand, W.C.
The President (H. J. Slack, Esq.) in the chair.

The Minutes of the meeting of 5th June were read and confirmed, and were signed by the President.

A list of the Donations since the last meeting was submitted and the thanks of the Society given to the donors.

The President said they had the pleasure of seeing amongst them that evening Professor Owen, who was their first President, and who had come to read a paper which he had sent to the Society.

The President said they would no doubt all remember that some time ago, Mr. McIntire presented to the Society a slide of the perforating proboscis of a moth, and in connection with it they would also remember that reference was made to a paper in 'Comptes Rendus' which described at some length a moth which possessed a similar perforating organ, and was reported as doing damage to oranges. A few days ago, he had received from Mr. Green of Colombo, through Mr. Curties, a specimen of a moth which was also able to perforate oranges in a similar manner, and it was described as hanging on to the fruit by means of the proboscis whilst it sucked the juice. On examining this proboscis, he found that it differed somewhat from those which had been described, in that it possessed a peculiarity which he hoped Mr. Green would work out. It seemed that the proboscis was armed with a series of cutting hooks, having cutting edges on both sides, thus enabling the insect to cut its way out as well as to cut a way into the fruit. At the base of these hooks or spikes was an organ which looked as if it might be a ball-and-socket joint, and the spike appeared to pass down to its attachment with this through a countersunk orifice, which enabled the spike to move through a large angle, and when extended would of course assist the creature to hang on in the manner described. He hoped that the attention of those of their friends who might be living in orange-growing districts, would be called to the matter with a view to ascertain if there were any other moths of this kind to be found, which might form an intermediate link between the two kinds already observed, and which presented very distinctive characters.

Figures in illustration of his remarks were drawn upon the blackboard by the President as he proceeded.

Professor Owen, C.B., F.R.S., &c., then read a paper "On the Fossils called 'Granicones,' being a contribution to the Histology of the Exo-skeleton in Reptilia," illustrating the subject by a number of drawings, and by sections exhibited under a microscope (the paper will be found printed in extenso at p. 233).

The President, in proposing a vote of thanks to Professor Owen for his paper, said that all would feel the interest it possessed, although as the subject was quite new it was hardly possible for any discussion now to take place upon it. He was sure that the Fellows would not only thank the Professor for his paper, but would also join him in saying that they were specially glad to be able to give him a personal welcome on account of his long connexion with the Society.

A vote of thanks to Professor Owen for his paper was unanimously passed.

Professor Owen said that it might be familiar to them all that so many of the fossil remains which were found in the Mesozoic strata —both of animals, plants, and shells—belong to a class of which the nearest living representatives are now found at the antipodes. Those beautiful specimens containing the well known teeth of Cestracion were well known, and there was still living in Australia a creature exhibiting the same kind of dentition and which was described as going along the reefs and picking off the Terebratulæ and crushing them between these teeth. The evidences as to the Stonesfield slate and similar formations, showed that all the individuals forming the group found there were Marsupials, the only living representatives of which class are now found in Australia. He had often been disposed to say, that the further they had to go in the strata for their fossils the further afield they had to go in the world for their present representatives; thus these things which had been puzzling him for so long were at last found to belong to a class of creatures which were only now represented by the horrid little lizard in Australia, *Moloch horridus.*

Mr. Crisp (Secretary) read a communication by Colonel Woodward, entitled "Further Remarks on a 'Simple Device' for the Illumination of Balsam-mounted Objects for Examination with Immersion Objectives whose Balsam Angle is 90°" (see p. 246), previously reminding the meeting of Colonel Woodward's first paper on the subject which appeared in the 'M. M. J.' of August, 1877. The original apparatus as there described, and the two prisms referred to in the further remarks, were placed on the table for examination.

He also read extracts from a letter from Colonel Woodward, stating that "he hoped to have something to say to the Society in the autumn about the treatment of *A. pellucida* in balsam by objectives of moderate power, but excessive angle amplified to high powers. To illustrate the possibilities of the method, he had sent a paper print of *A. pellucida* in balsam as shown by a Spencer duplex $\frac{1}{10}$, of rather more than 110° balsam angle, amplified so as to give equal powers with equal distances to those given by Powell and Lealand's $\frac{1}{25}$. The whole frustule shown on the print was ·0038 of an inch long, so that the magnifying power obtained was about 2420 diameters, and he thought it would be said, with very little distortion and good resolution of the lines from end to end. The striæ on this frustule were, as would be seen by counting the number to the inch and multiplying by the magnifying power, about 100 to the $\frac{1}{1000}$ of an inch, so that the test was sufficiently difficult. On the whole, the result seemed to him quite satisfactory, but there was a certain muddiness in the picture, due to the use of an old amplifier which needed repolishing. He was having some new amplifiers made with which he expected to get more sparkling pictures."

The photograph accompanying the letter was handed round for examination; it showed the striæ with remarkable distinctness.

Mr. Ingpen inquired if any question as to priority in regard to the invention or use of this prism arose out of the paper. He had himself seen a prism with four faces, made by Messrs. Powell and Lealand, from drawings by Dr. Edmunds, which appeared to more than cover the ground aimed at by the prisms now shown.

Dr. Edmunds, in reply to a question from the President, said that, as to the prism to which Mr. Ingpen had referred, he had not thought it of sufficiently marked novelty to make it the subject of a formal communication, but he would be pleased to submit it to the next meeting. Upon the question of priority, it would be recollected that in 1856 Mr. Wenham described a small right-angled prism, which he attached to the under surface of the slide with oil or balsam, and used for oblique illumination. This application of a right-angled immersion prism was clearly due to Mr. Wenham. What was due to Colonel Woodward in his beautiful work was not the invention of the right-angled prism, but its combination with a pin-hole shutter, through which a small beam of parallel light could be thrown into a balsam-mounted object outside the angle of 41° from the optic axis; thus demonstrating that pencils outside 82° balsam-angle could be used to form an image if only the objective were of sufficiently large aperture. With reference to his own prism, he had had the advantage of working with that sent over by Colonel Woodward, and finding it difficult to manage, and that its corners practically prevented its rotation under the slide, he had had another form constructed by Messrs. Powell and Lealand, and this had proved most useful and very easily managed. It was made from rather more than a hemisphere of glass, of which the spheroidal surface was ground down into four faces making practically two right-angled prisms at right angles to each other, one having its faces inclined to the plane surface at 41° and 49°, and the other at 30° and 60°. The prism was set in a simple brass tube with a slot for each face, and fitting below into the substage. The faces were so arranged that an object in focus was illuminated equally through each face by light entering it at the normal. The upper surface was $\frac{7}{8}$ inch in diameter and was made optically continuous with the slide by oil or glycerine. By simply turning the substage, the prism gave unrefracted light at 30°, 41°, 49°, and 60° from the optic axis, and each angle could be varied a little without practical detriment. The light reflected from the top surface of the prism passed out through the other side at the normal, and thus glare was prevented. The prism worked charmingly.

Mr. Crisp said that the interest of Colonel Woodward's present apparatus arose entirely out of the angle of aperture discussion. Colonel Woodward certainly had never claimed and did not intend to claim the invention merely of a right-angled prism for illuminating objects under the microscope, but obviously the particular application of such a method for the special purposes dealt with by his paper. As Dr. Edmunds had said, the right-angled prism was undoubtedly not "new"—indeed it had become very difficult to substantiate a claim to actual novelty as regards the mere form of any illuminating apparatus, as things seemed to be re-invented over and over again in more or less regular cycles. Mr. Wenham, who was admittedly the "first and true inventor" of the right-angled prism, used it, however, entirely for the illumination of objects under high powers by total internal reflection from the upper surface of the covering glass. Those curious in the matter would find a summary of the various analogous devices of Mr. Wenham and others in the second German edition of Harting's 'Das Mikroskop,' the figures in which he showed to the meeting. Canada balsam or other medium was interposed between the prism and the slide in Mr. Wenham's arrangement for the purpose of preventing the rays from being reflected from the back of the prism instead of passing on to the covering glass.

Mr. Crisp (Secretary) said that a Congress of American Microscopists had been held in August at Indianapolis, at which the subject of a "Unit of Micrometry" had been taken into consideration, and he read the Resolutions which had been passed by the Congress recommending the use of the $\frac{1}{100}$ of a millimetre (see p. 254).

Mr. Beck inquired if it was intended to take any action with reference to the Resolutions. The desirability of a uniform standard had always been appreciated in this country, and it would be a very desirable thing if the Society would now give the weight of its influence towards the establishment of such a standard. Some time ago the adoption of a single thread for the screws of all objectives was due to the action of the Society, and though perhaps the one decided upon might not be the best, yet the adoption of a uniform gauge had been of very great advantage in the way of getting rid of those horrible nuisances, the adapters. He merely threw out the suggestion because he thought the idea was worth their consideration, and he should like to know whether or not the Council were prepared to take any action in the matter.

Mr. Crisp added that at the Congress a paper had been read by Professor W. A. Rogers, of Harvard University, in which it was understood that he had explained the application of a machine he was using for the production of "standard" micrometer scales, and by means of which he believed that he could rule any number of micrometers precisely alike and with exceptional accuracy. It should not be forgotten that, as Mr. Reeves reminded him, the subject of a uniform micrometric standard had been very completely dealt with by Dr. Cooke in a paper read before the Quekett Microscopical Club, and printed in their Journal on p. 1 of vol. i.

Mr. Beck, in reply to the President, said there would be no difficulty whatever in obtaining scales ruled as required for the adoption of the proposed standard.

Dr. Edmunds thought that the whole question of microscopical measurements wanted going over and revising. It had been said that there was a Society's screw for objectives, but when he wrote to the Assistant-Secretary to ask him for a standard gauge, he was told he could not be supplied, and so he found that his mounts of Powell and Lealand's would not fit Ross's, and that Smith and Beck's again differed from these.

Mr. Beck said, there certainly was a standard in the possession of the Society, which was made by Whitworth at the time the question was settled, and there could be no doubt that by applying to Whitworth they could get others so exactly the same that all made to it must accurately fit one another. The differences now complained of were owing to makers not having revised their screw tools from time to time, so as to ensure that they were accurate.

Dr. Edmunds said that there were also other questions that should be pronounced upon by the Council. For instance, what is the "10-inch" tube? In practice the length varies with each of the makers, and the eye-pieces are so constructed as to destroy all uniformity in the datum point at the eye end of the tube. Practically the eye end of the tube measured from the diaphragm in the eye-piece. Nevertheless the 2-inch eye-piece—one of the chief makers only excepted—was shouldered about an inch beyond its diaphragm. On the other hand the ½-inch eyepiece necessarily has its shoulder about on a level with its diaphragm. It followed that in changing the 2-inch eye-piece for the ½-inch the optical tube was lengthened no less than an inch. Therefore the amplification given by the objective at the point where it was taken up by the eye-piece, was greatly increased while the objective itself needed to be readjusted, and to have its focus shortened before it was fit to be viewed by the ½-inch eye-piece. Yet all this could be remedied by the simple plan of shouldering the eye-pieces on a level with their diaphragms. Then again, why should not the visual and substage tubing of the large microscopes always be of the same size? At present several of the chief firms made their substage tubing different in gauge from their own visual tubing, and consequently the eye-pieces could not be used for condensers. Nor was there any adequate reason why all the large microscopes, and on the other hand, all the small microscopes, should not be made to a standard gauge, so that apparatus made by various makers could be used indiscriminately.

The President said that as to the standard of the Society's screw, that was carefully kept in the possession of the Council, and copies could no doubt be obtained from Whitworth if they were required. With regard to the present discussion, it would be understood that Mr. Beck would be kind enough to give them his ideas on the subject of micrometric measurements, and that Dr. Edmunds would similarly undertake the other questions as to size of screw, tube, &c.

A letter was read from Mr. F. Habirshaw, of New York, in reply to one addressed to him by Mr. Crisp in reference to the discussion that had recently taken place on the "Revification of Diatoms," and particularly the note on p. 150, in which Mr. Habirshaw said, "Without doubt, the diatoms were alive. Nothing was used but filtered water from the ship's tanks, and I have not the least doubt as to their revification. Captain Mortimer is an accomplished naturalist, and not a man to make idle assertions, or be easily led towards error."

Mr. Crisp described and exhibited (1) the "Miniature Microscope" of Mr. Browning (see p. 296), intended as a more powerful substitute for a hand lens, and capable of holding ordinary slides. The one exhibited, which was in nickel silver, was examined by the meeting. (2) The "Transporteur Monnier," which was said to remedy the annoyance occasioned by displacement of an object (which had been carefully arranged in the proper position in glycerine, &c.) when the covering glass was put on (see p. 265). Whether there was any such an evil to be corrected, those who were more experienced in mounting than he was would be able to say. (3) An objective made by the Bausch and Lomb Optical Company, of New York (under Mr. Gundlach's patent), with the "new" correction adjustment (see p. 252). Mr. Ingpen undertook to examine the objective, and to be prepared to say something on the usefulness or otherwise of the addition at the next meeting.

The President announced that the first of the "Scientific Evenings" for the present session would take place on Wednesday, 27th November, when he hoped the Fellows would assist in making the meeting as interesting as the previous ones had been.

Donations since the June meeting (exclusive of exchanges):—

	From
American Journal of Microscopy, April to September	*The Editor.*
Cox, J. D., Dr., *Isthmia nervosa*, a Study of its Modes of Growth and Reproduction. (From American Journal of Microscopy, vol. iii.)	*Author.*
Dallinger, Rev. W. H., On the Life-History of a Minute Septic Organism. (From Proc. Roy. Soc., vol. 27)	*Ditto.*
Fischer, Prof. A., Le Microscope Pancratique, 1841	*Mr. Frank Crisp.*
Naturalists' (U.S.) Directory for 1878	*Mr. F. Habirshaw.*
Journal of the Cincinnati Society of Natural History. Vol. I., Nos. 1 and 2	*Society.*
Memorias da Academia Real das Sciencias de Lisboa for 1875 ..	*Academy.*
Mineralogical Magazine. Vol. II., No. 9	*Society.*
Orth, Dr. J., Cursus der normalen Histologie, 1878	*Mr. Frank Crisp.*
Sessão Publica da Academia Real das Sciencias de Lisboa, 1875 and 1877	*Academy.*
Proceedings of the Geologists' Association. Vol. V., No. 6	*Society.*
Eighth Report and Abstract of Proceedings of the Croydon Microscopical Club, for 1877	*Club.*
Verhandlungen des Naturhistorisch-Medicinischen Vereins zu Heidelberg, 1878	

The following gentlemen were elected Fellows of the Society:—

Major A. Morton Festing, F.M.S., Staff Paymaster Army Pay Department; John Borland, Esq., Member of the Pharmaceutical Board of Examiners for Scotland.

WALTER W. REEVES,
Assist.-Secretary.

JOURNAL

OF THE

ROYAL MICROSCOPICAL SOCIETY.

DECEMBER, 1878.

I.—*On a Species of Acarus, believed to be new to Britain.*

By A. D. MICHAEL, F.R.M.S.

(*Read before the* ROYAL MICROSCOPICAL SOCIETY, 1*st May and* 13*th December*, 1878.)

PLATE XVI.

Cheyletus venustissimus.

IN the beginning of January last (1878) I found this species, which I believe has not hitherto been detected in Britain,* in a stable; near Tamworth I noticed one or two minute red specks running rapidly over the fodder. I secured three or four for examination, and I then ascertained that it was the *Cheyletus venustissimus* of Koch;† that author, in his work published in 1839, describes and figures the species in a manner sufficient for identification, although somewhat wanting in detail; he states that it was then found in the neighbourhood of Regensburg and in Rhenish Bavaria, and was somewhat rare.

The species is not noticed by Walckenaer and Gervais, and I am not aware that any subsequent author has noticed it, except by stating that Koch gives it as one of the genus; as Koch's notice is not very full and does not mention the larva, pupa, &c., a description may possibly be acceptable.

EXPLANATION OF THE PLATE.

Cheyletus venustissimus.

FIG 1.—Under side of female × about 70 (the imbrication of the hairs is somewhat exaggerated); *a*, horseshoe-shaped ridge round anus.
„ 2.—Rostrum and palpi × about 200; *a*, first joint of palpus; *b*, second ditto; *c*, falx; *d*, third joint of palpus.
„ 3.—Larva.
„ 4.—Foot highly magnified.

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* Subsequent to the reading of this paper Mr. McIntire was good enough to show me a slide of unnamed *Cheyletus* captured by him. It has been mounted some years, but I think it quite possible that it may have been this species.

† 'Deutschland's Crustaceen,' Heft xxiii. p. 22.

The species, while thoroughly preserving all the above-named characters of the genus, which are very marked, is, as far as those characteristics will allow, a complete contrast to that last described, its red or orange colour, lighter build, and longer legs, evidently adapted for speed and activity, making it a remarkably different-looking creature.

The median stripe in this species is very conspicuous, and extends from the widened œsophagus to near the anus, and is formed by the alimentary canal showing through the skin; the normal shape of the stripe is that of an hour-glass, and the colour is opaque white; the shape of the marking, however, varies considerably, both in different individuals, and in the same individual from time to time, according to the position of the food in the canal, and the quantity contained. The body on each side of the median stripe is red or orange, the palpi, legs, and œsophagus clear light yellow or yellowish white.

The shape of the body, as in all the Cheyleti, is diamond or coffin shaped, with the anterior part of the diamond shorter than the posterior, and the front and anal angles rounded off, the points of the lateral angles being formed as in the last species; but the body in *Venustissimus* is longer in shape, being nearly twice as long as it is broad, without the rostrum, and much flatter, the thickness not being above a sixth of the width at the widest part. The diamond shape is not so conspicuous as in the last species; the body is marked by five slight constrictions, which produce a somewhat scalloped outline; the constriction between the cephalothorax, which occupies over two-thirds of the whole bulk, and the abdomen, is only slightly marked on the upper side or at the edges, but on the under surface it is marked by a very deep depression, widest on the ventral surface, and narrowing inwards; the raised median portion of the under surface of the cephalothorax slopes suddenly down from nearly opposite the insertion of the fourth pair of legs to the bottom of this depression, forming a blunt oblique triangle. The anus is placed in the centre of a strong horseshoe-shaped ridge, with the points drawn out laterally, which is marked with numerous folds, and is probably contractile. The skin of the legs, palpi, and under side of the body is very finely striated; the striation is, however, not nearly so strong as in the last species, and on the body the colour renders it difficult to see.

The anterior pair of legs are far the longest, and very thin and fine; these legs constitute the most marked characteristic of the species, being strikingly different from the comparatively short firm legs of the other Cheyleti, particularly the last species. The coxa is short, stouter than the other joints, and is somewhat angled on the posterior side. The second joint (or trochanter) is long and straight; it is decidedly striated. The third joint (the femur) is not much above half the length of the second. The fourth joint* is nearly as long as the second, and has the inner side of the posterior articulation projecting. The tarsus has a slight shoulder a little beyond the articulation, from this point it narrows in and becomes very fine; the tarsus is the longest joint of the leg; the tarsal sucker of this particular leg is small and fine, and the claw very small and difficult to make out.

The use of this first pair of legs, and the distribution of the hairs on all the legs, are mentioned below.

The second, third, and fourth pairs of legs, although longer than in the last species, do not vary from the usual type of the genus sufficiently to render it necessary to describe them. The sucker and claw and its supports are given in the drawing (Plate XVI., Fig. 4).

There is a row of seven or eight strong hairs on the upper side of the body, a little within the edge, the first three near together; each coxa bears a strong short curved hair pointing downwards and towards the foot. The first pair of legs have on the second joint two longer straight hairs a little beyond the middle, one on the upper and one on the under side; on the third joint two similar on the upper side, a little before the middle; on the fourth joint two similar at the commencement on the outer and upper side, and one short one on the hinder and under side, one short and one long about the middle of the joint, and one very long strong one on the upper and outer front end of the same joint, this is the longest and strongest hair on the creature; on the tarsus there is a similar hair, not quite so long as the last, springing from the upper surface at the before-mentioned shoulder. All these hairs are conspicuously imbricated, like those of the Indian bat; on each side of the point of the tarsus is a long strong hair, and in the centre is a shorter and finer one; these hairs are closely jointed or ringed, but are not imbricated.

The second pair of legs have a pair of hairs on the third joint, and two pairs on the fourth joint, all imbricated; one small one half-way down the tarsus, and two pairs at the extreme end, all small and plain. The third pair of legs have a pair of hairs, and the fourth pair of legs one hair on the second joint, the hairs on the remaining joints being like those of the second pair of legs.

The palpi in this species are without teeth on the falces, otherwise like the last species but slighter (Plate XVI., Fig. 2).

It is well known that in the acari the first pair of legs are modified palpi, and M. Robin has remarked that in some instances they appear not entirely to have lost the office of organs of touch;

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* This joint is called the tibia by Nicolet. Robin rejects this name, and calls it "la jambe," following Savigny in reserving tibia for the lower half, where this joint is divided into two shorter ones.

my observations on the present species lead me to the conclusion that it is a striking instance of this, indeed it would be more correct to say that they have hardly acquired the office of legs; they do not seem to bear any of the weight, but when the creature is moving, they are held slightly elevated, nearly horizontal, are constantly trembling, and seem to touch the ground very lightly at every step, and when the mite is about to ascend any obstacle, they are always put out, evidently to feel, first, but it does not climb by them.

I brought one living specimen from the country on the 5th of January, 1878 (the other two or three which I had caught having been mounted), by confining it in the manner before named, with a little dust from the fodder; I kept it alive for nearly three months, it became quite accustomed to its cage, and seemed, up to the time of its death, on 29th of March, which was after it had deposited its eggs, and some of the young had emerged, strong and well. Its habits seemed different from those of the last species; it used to lie in wait with the front legs, and the palpi widely extended, and generally hanging from the under surface of something; whenever I have put a cheese mite near it, or whenever I have seen one go there, it has retreated without attacking them, but those I put in one day were almost always dead and sucked dry by the next day. On one occasion only I saw it seize its prey: then the cheese mite came well between its palpi, and with one vigorous stroke it drove the great falces at the end of the second joint right into the body of the mite, and then plunged its rostrum in, and the mite was dead directly.

I brought the creature from the country, as before stated, on the 5th of January, and put it alone in the cell, inspecting it very frequently, hoping to breed from it, but for a long time I was unsuccessful, and began to fear it was either a male or unimpregnated female; on the 19th of March, however, I saw a nymph emerge from under the dust. I examined, and found some eggs, which could not have been there long. The next day a larva appeared, and I have subsequently bred others. I cannot ascertain that anyone has before discovered any of the earlier stages of this species. Koch does not mention them.

The eggs are short ellipses with blunted ends, very polished, and of a pearly white; they are laid singly, i. e. apart from each other, and each egg is attached to the substance it is laid on by a few very fine threads.

The larva is hexapod; much smaller and shorter than the perfect creature, but otherwise similar in form; the colour, however, is clear yellowish white or light yellow, like the legs of the adult; the front legs are similar, but the tarsus is terminated by a single long bristle instead of two, and this one, although springing from the outer side, is sharply bent round almost immediately, so as nearly to continue the line of the leg.

The nymph is octopod, very like the perfect acarid, but smaller and shorter; it has the red colour of the adult.

Since the above paper was read I have succeeded in finding the male. I continued breeding the creature in hopes of obtaining it, but without result, until nearly the end of August, when suddenly a batch appeared nearly all males. The chief differences between them and the females are that the former are considerably smaller in size, about ·018 inch long instead of about ·025, which is the average length of the females. The body in the male is more elliptical, less diamond-shaped, the difference in shape being mainly the result of the smaller proportionate size of the mammillary process at the side. The anus, moreover, is prolonged in a short point, whereas that of the female is rounded. The penis, which is very long and cylindrical, is retractile within the abdomen, but emerges at the posterior end immediately above the anus, an arrangement unusual among the Acarina. The legs are rather stouter in proportion in the male and the hairs less strongly imbricated, and the inner pair at the posterior of the abdomen are smaller. I am not aware that the male has been previously observed. It is difficult to account for the males appearing so suddenly, but possibly the *nubile* females may be found at one time of year only—this I have not yet ascertained.

II.—*On the Visibility and Optical Aspects of Hairs viewed from a Distance.* By Henry J. Slack, F.G.S., President R.M.S.

(*Read before the* Royal Microscopical Society, *November* 13, 1878.)

Dr. Royston-Pigott's observations on the visibility of minute objects suggested the following experiments. The first was to try at what distance persons of average good sight could see a human hair $\frac{3}{1000}$ inch in diameter, and eight or nine inches long, fixed by a little gum at each end to a window-pane of plate glass. Five persons, three being ladies of different ages, all saw it distinctly at 34 feet, against a whitish sky. By shifting the position of the observers the background could be varied with different sky tints, or by bringing rich green cypress trees into view. A white cloud as background gave the best result; the dark trees answered well in some lights, and clear bluish sky considerably shortened the distance of visibility. These trials were made with the hair on a northerly window, by observers looking at it from the north-east. The day was fine, and the time about 10.30 and 11 a.m. on the 3rd November. Similar results were obtained on other days.

Immediately after these experiments on the 3rd November, a similar hair was stretched vertically across a small pane of glass, which was raised about 10 feet on a pole, placed to the east, and with clear sky behind it; the sun being within an hour or less of south. One of Browning's Panergetic opera-glasses, with 2¼ field lenses, and excellent corrections, magnifying rather less than 2, enabled one of the party to see the hair instantly at a distance of 50 yards. The other four all saw it with the same instrument, but had to take great care, and succeeded best by steadying themselves against a wall. The spectators all stood in the shade.

It being obvious that a pane of glass behind the hairs might affect the vision, a frame was made of deal lath, with an opening 5 inches square, and two hairs $\frac{3}{1000}$ inch in diameter stretched across it at right angles to each other. This frame was fixed to a post, so that the crossed hairs could be seen in full face from either north or south. The time was 9th November, from 10.15 to 11 a.m.; the sky being very clear and sun brilliant. Standing with our backs to the sun, both hairs were distinctly seen by my wife and self, at a distance of 29 feet, with a bluish grey sky for a background. When a sheet of white paper was placed behind the frame, the hairs were visible at nearly 46 feet (45 feet 6 inches).

By this time the sun was rapidly gaining a position most favourable to a brilliant illumination of both hairs, but especially the horizontal one. The hairs were then viewed from the north, and seen at a distance of 76 feet with a clear bluish sky background and naked eye. By a slight shift of position the sky background was exchanged for a white wall, and the hairs were seen at a distance of 113 feet. Just about eleven o'clock the sun lit up the horizontal hair with a brilliant glow, and then an image, formed by it, was distinctly seen at the great distance of 173 feet, but the appearance was not at all hair-like. It was far too broad, and not sharp at the edges. The opera-glass did not make it look like a hair, but left no doubt that the hair caused the image, and that the image corresponded with it in position and length. A pencil was then held over the horizontal hair and seen with the opera-glass, without distortion. As soon as the sun's motion carried it from the most favourable position for lighting up the hair, it ceased to give any image visible at a long distance.

In experiments with hairs attached to a window-pane, it will be found that the quantity and direction of the sunlight, and the colour of the background, and its degree of illumination, all affect the apparent diameter of the hairs. A diffused rain-cloud with a good deal of white light in it, gives a small diameter, and very sharp definition. Taking this as the most correct aspect of the object, any change of conditions which makes it look broader must be regarded as introducing optical errors, and it may be remarked that when, after viewing a hair two or three feet off, it is viewed at 15, 20, or 30 feet off, it does not seem to have its diameter diminished, as would result from perfectly accurate vision.

So long as the image seen by the eye corresponds tolerably well with the true aspect of a hair, it is fair to say, "I see the hair;" but when such aspects are afforded as in the experiments with full solar illumination the hair is not seen, but only the effect of its reflexions and refractions on the solar beams.

If an observer, seeing this appearance, concluded that the frame had a band across it in a central position, he would be right; but wrong if he attempted to estimate its breadth, or to decide upon the nature of the substance composing it. This is a case of a kind of vision giving some information that corresponds with fact, coupled with other information that differs widely from fact; and an inquiry suggests itself whether a good deal of vision obtained with high powers and peculiar illumination does not partake of this character.

On the 12th November, the sunshine being brilliant and air clear, the experiments were repeated. At 10 A.M. both hairs were sharply seen at 105 feet, without distortion. At 10.12 the horizontal one was seen at 110 feet, and at about 115 feet twelve minutes later. The sky then became hazy, and the hairs invisible at the long distances.

About four o'clock on the 11th November, when walking up a hill two or three miles south-west of East Grinstead, the vanes standing above the angles of the four square towers caught the sunlight and gave the appearance of a broad golden band suspended in the air above the tower. The vertical diameter of this band far exceeded the optical angle under which the vanes would have appeared if it had been possible to see them correctly with the naked eye; but there was no error of position, and the grouping of the vanes in one unbroken line simply arose from the distance being too great for the interspaces between them to be noticeable. In such a case what is seen? Certainly not the vanes, but a well-defined optical image differing considerably from them. The non-correspondence of this image with fact was inferred partly from the observers having seen the vanes at a short distance, and partly from the improbability that anyone had suspended a broad gilt band in such a situation. Had there been no knowledge of the real structure and no improbability in there being a broad gilt band over the tower, the optical appearance might have led to a belief in its existence. May we not suppose that microscopists are sometimes in danger of being misled by appearances they have no means of bringing to any decisive test?

III.—*On the Measurement of the Angle of Aperture of Objectives.*

By F. H. Wenham, F.R.M.S.

(*Read before the* Royal Microscopical Society, *November* 13, 1878.)

In arranging in the form of a paper, some recent investigations on this yet undecided question, I have no desire to maintain a controversy that has at times appeared as one of personal feeling instead of scientific reasoning. The facts cannot be established by a majority of opinions, but by actual experiments. It is to these principally that I now refer.

Professor Stokes, at the meeting of this Society held in July last, has brought forward a question, and shown in theory that by means of a front lens, with an emergent surface exceeding the hemisphere, a ray may be refracted within the substance of the glass in a direction at right angles to the axis or at an angle of 180°. He then remarks that if the reduction of the surface be to a hemisphere, " the aperture in glass, though reduced from the extreme of 180, still remains very large."

It is with front lenses having refracting surfaces less than a hemisphere that we have been dealing, and to such Professor Keith's paper on the Tolles $\frac{1}{6}$ refers. It may be stated that we are not seeking for foci within the front lens, or yet on its surface. An immersion lens is not useful for viewing diatoms in balsam only. Every lens that I have seen professing 180°, whether it has an adjustment or not, is expected, and does, in fact, focus upon dry mounted objects. This necessitates a correct focus at a little distance beyond the last surface, from a position which must include a less air angle than 180°, and is consequently within the critical angle of nearly 82° in the crown glass.

The $\frac{1}{6}$ referred to belonging to Mr. Crisp has considerable focal distance in air, and I am confident that when the axial angle is correctly measured it will be proved far short of 180°, and the whole of Professor Keith's calculations concerning it must fall to the ground. The practical obstacles which have hitherto prevented the construction of any objective reaching to an air aperture of 180° still exist.

As much importance, both theoretically and practically, appears to have been attached to the last few degrees of extreme angle of aperture verging upon 180°, I repeat that the value of aperture in theory, considered as a question of rays collected, is palpably as the chord of the arc including the angle, or, in other words, in proportion to the sine of the half angle; for large angles so small is the comparative increase, that the difference between 170° and 180° is only as 99·6 to 100. But setting theory aside in this question as not always working harmoniously with practice, let it be considered, experimentally, what is the probable importance to definition from rays proceeding at extremely oblique angles from flat surfaces having a raised configuration or structure. Take, for the first example, a piece of coarse-grained canvas or other fabric. Throw light upon or through this obliquely, and examine it at various angles with a shallow magnifier. At visual incidences greater than 45° or 50° no advantage will be gained; on the contrary, there will be a positive loss of definition. The same effect is seen on a different surface consisting of uniform glistening particles, such as bird-seed. To this dissentients will say, "You are comparing observations under a low magnifying power or with none at all to those made with the microscope," but relatively the conditions do not differ. Perhaps the most trying work for a hand magnifier is in examining the polish of glass surfaces in order to ascertain if all the "greys" are worked out. For small lenses a half-inch achromatic is used, held at an angle of about 45°; at a greater angle the extremely fine specks cannot be discovered. Light is directed at a great obliquity on the surface or is transmitted. Uneducated workmen do not reason about any theory of angles, but adopt the one that gives the best result, simply because they find out at once that it does so.

My argument is that the angular aperture of microscope object-glasses has hitherto been erroneously measured by all the usual means, in which the outer oblique rays extending to the margin of the field of view have been in all cases included, and, in fact, constitute the false measurement. The true angle is the cone of rays diverging from an atom or point in the centre of the field. Other pencils of greater obliquity defining atoms at the margin, are exclusive and independent of the central rays as much as the different objects themselves, yet it is the direction of these exterior rays that we have hitherto been measuring. There seems to be an absence of experiment, or disinclination to admit the evidence of such an error. For one proof of an example wherein angle of direction is erroneously measured as angle of aperture, unscrew and remove the back lenses of high-power objectives, and measure the apparent apertures of the *fronts alone* by any of the usual methods, such as the traversing sector, or by the angle of direction to two distant images. The angle of the front lens alone of a $\frac{1}{5}$ thus measured came out as 83°, simply because the back lens included nearly a hemisphere, which admits lateral rays from a wide angular direction. The aperture of the front of a $\frac{1}{10}$ appeared as 110°, and that of a $\frac{1}{15}$ as 122°, because more rays entered sideways, as the back surface in these last lenses is almost a hemisphere. This exemplifies the absurdity and utter inaccuracy of the usual mode of measuring angle of aperture, as we know that these single lenses have in reality an angle of aperture of a few degrees only.

In order to define more clearly the direction of these outer rays, that cause indications of false aperture, I tried the following experiment. I selected a $\frac{1}{5}$ which worked as an immersion, as this position prevents confusion concerning other points of adjustment. The full aperture, as measured by the sector through a slide with water between that and the front lens, was 120°. The focal distance as immersion was ·041. The diameter of transmission on the surfaces of front lens was ·07, ascertained by allowing a drop of milk to dry on the front and measuring the diameter of the light spot from parallel rays entering from the back, using a low-power object-glass and micrometer eye-piece for the measurement.

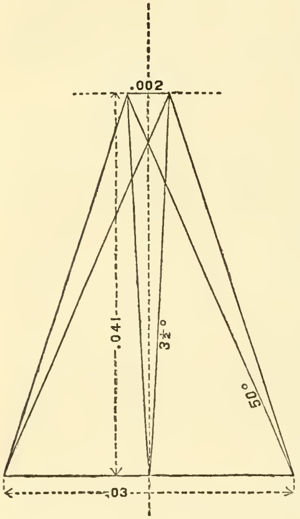
The field of view included a diameter of ·03 on a stage micrometer. With the exact focal distance from the front lens as a starting point, it remained to ascertain what were the *apparent* apertures taken through various stops of definite diameter set close to the front, that could only admit the base of a cone of rays from an angle proceeding from the axial focal point up to a known diameter of stop. The arrangement that I use is a form of adjustable slit, consisting of two strips of very thin platinum foil; one piece is cemented on to a slip of thin plate glass, which is made to slide under two staples by a micrometer screw acting against a counter spring. The fixed strip of foil is attached to one of the staples, so that when the screw is quite home the edges meet. The various widths at which the instrument was set were measured under the microscope with an eye-piece micrometer. Having got the desired width, the object-glass to be measured was attached, and the body of the microscope lowered till the slit came in contact with the front lens, a drop of water having been placed over the slit to prevent undue refraction, and obtain more light.

The apparent angles included by these limiting edges or stops were measured by the usual sector method, of rotating the microscope on a turn-table graduated into degrees, and ascertaining the vanishing point of a distant light; or, preferably, by means of an examining lens at the eye-piece, for observing the disappearance from the field of an actual image.

The real or true angles were estimated from the distance of the focal point, up to the known measure of the edges of the stop. Avoiding fractions of degrees, the following table gives the comparative results:—

Working Diameter of Front Lens.	False Aperture.	True Aperture.	Working Diameter of Front Lens.	False Aperture.	True Aperture.
·07	120°	89°	·02	68°	31°
·06	118	80	·01	59	16
·05	116	70	·005	53	8
·04	103	58	·002	50	3½
·03	88	45			

The last item obtained with a stop $\frac{1}{500}$ of an inch in diameter, indicates an aperture of 50° by the usual methods, whereas the true angle is only 3½°, an error being shown in excess of more than fourteen times. The annexed diagram demonstrates the cause of this error. The central angle shown is the true aperture assigned by the small stop at the base. The oblique angles represent the pencils, including the field of view, and showing light or an image at the eye-piece, up to an angular range of 50°. It is these outside rays which are superadded to angle of aperture taken by the usual method, and which are the cause of erroneous indications greatly in excess of the true angle.



The foregoing is a mere illustration of excessive angles, indicated from oblique pencils, or angle of view alone, irrespective of true angle of aperture, for, of course, limiting stops of known diameter placed on the front lens serve no purpose for measuring full central angles. The difficulty of estimating the degrees of these angles accurately, by such minute measurements as the focal distance, and working diameter of the front lens, may be avoided by halving this as an unknown quantity, and obtaining the value of the central angle by the differential results, shown between a half-obscured front surface and an entire one. That which is understood (and, in fact, always has been) as a definition of angle of aperture, in a micro object-glass, is a triangle having a base equal to the available diameter of the front lens, and a height equal to the focal length measured therefrom. Now it is clear that if half the front lens is stopped off diametrically close to the surface, only half the base of the triangle must remain, and consequently but half the existing angle or cone of rays in the axial direction. By the sector measurement such is not shown to be the case. The apparent degrees from a half diameter of incident front surface are much in excess of a half quantity, because the rays that form the oblique pencils extend behind and under the half stop, nearly to the margin of the field of view beneath. These are beyond the true axial angle of aperture, and are the cause of the false quantity always measured in excess of the proper angle, the rays including the angle of field must therefore be deducted up to the centre. This the half stop enables us to accomplish. Using the sector measurement the rule is this. *Subtract the degrees shown by half the lens from* *the degrees of the entire lens, and twice the difference is the aperture.*

By this simple rule we eliminate the angle of field, which has hitherto been erroneously added to angle of aperture. In order to obscure the half of the front lens, take a small piece of tinfoil with a clean-cut edge, lay this on a glass slip, and smear its upper surface with a bit of dry soap (anything moist will bedew the glass), place this on the microscope stage, and bring the edge in focus under the object-glass, until it exactly bisects the field vertically. Then lower the object-glass on to the foil, which will adhere to the front lens. The microscope body may then be laid horizontally, and the apparent aperture of the open half of the lens measured by the sector, which invariably indicates considerably more than half of the full aperture, taken by the same method. In objectives of large angle, twice this half measurement will amount to absurd and impossible angles.

The application of the above rule will require to be thoroughly investigated before it can be finally adopted. In every case it brings out a reduction on the degrees of aperture indicated by all the modes of measurement in present use. I give its test, on what I have repeatedly stated to be fabulous apertures, viz. 180°. I have one of these objectives—a $\frac{1}{10}$—yet in ridiculous disproof of such an aperture (which would bring the focal plane on to the surface of the front lens), it is remarkable for its working distance, and will penetrate through the cover of any object in my cabinet, and used with thick covers, either as immersion or dry, its performance is very fine. Taken by the sector, the open aperture, or what I will term angle of field, is 180°. The aperture of half this lens is 115°, twice the difference is 130°; this represents the degrees of the central pencil, which is the true aperture. I take another example of an immersion lens, in which the maker actually claims "plus 180°." On trying this by the sector, the light image vanished at a range of 178°, beyond which it was totally obscured. The aperture of half the lens was 114°, twice the difference is 128°.

IV.—*Improvements in the Micro-spectroscope.*

By F. H. Ward, M.R.C.S., F.R.M.S.

(*Read before the* Royal Microscopical Society, *December* 13, 1878.)

Plate XVII.

Early in this year we were reminded by Mr. Crisp * that one of the objects of this Society was the promotion and diffusion of improvements in the optical and mechanical construction of the microscope, and as during the last twelve months I have been making some experiments with a view to modifications of the micro-spectroscope, and have just received from the maker an instrument which differs in several particulars from the usual form, I have ventured to bring it before the Society, and after pointing out the features in it which I believe to be new, shall leave it in your hands to decide whether it is an improvement or not.

One of the first things which struck me as being an imperfection in the ordinary instrument was the slit, and the facility with which its jaws collect dust, thus causing those objectionable black lines across the spectrum, and though when the spectroscope is to be used in conjunction with the microscope the slit is much more protected from dust than in a table spectroscope, yet, nevertheless, from its internal position it is more difficult to get at, and sometimes little particles remain after several attempts to remove them. I cannot claim to have done much work myself in this branch, but I am told that with an instrument in constant use, the slit is liable to get out of order, and requires adjustment to maintain the perfect parallelism of the jaws and the integrity of their opposed edges.

As soon as I began to make inquiries on the matter, I found I was by no means the first who had recognized these difficulties, and that during the last twelve years others had been considering what could be employed as a substitute for the slit. Returning one night from one of our meetings, it suddenly occurred to me that if a rectangular glass prism was taken and the apex of the right angle carefully ground off and the resulting face polished, it would transmit a narrow pencil of light, which would work admirably in spectroscopic examinations, any light falling upon the sides of the

DESCRIPTION OF PLATE.

Fig. 1.—New micro-spectroscope.
„ 2.—Plan of internal platform, showing prism fitting, with three prisms *in situ*, comparison prism with slot, &c.
„ 3.—Tube carrier for comparison stage.

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* 'Journal of the Royal Microscopical Society,' vol. i. p. 121.

prism being at the same time totally reflected. I thought the matter over for several days, and then conferred with Mr. Hilger, than whom I suppose no more competent authority exists on the construction of instruments for all the branches of spectrum analysis, and the result was a visit to his workshop with some prisms to put the matter to the test. A few minutes sufficed to remove the right angle from the prisms, and a few touches on the polisher gave a brilliant but narrow surface, quite sufficient to indicate as a rough experiment whether the method were likely to answer if more carefully carried out. Not having a microscope at hand to which it could be easily adapted, and wishing to submit the plan to as severe a test as possible, we opened widely the slit of a table spectroscope and secured the prism in the centre of the opening. The battery of this instrument consisted of four large prisms, each with an angle of 64°, the faces of which had a width of three inches, and as it was so arranged that the ray should traverse them four times, the length of the path in the centre of the prisms was about 25 inches. Placing some sodium salt in a Bunsen flame, we tested the result, and found the D lines well separated and beautifully distinct and sharp. We also tried lithium, calcium, and carbon, and the results were equally good.

I was so pleased with what I considered the success of the attempt, that I directed Mr. Hilger to construct me an instrument for my microscope in which three prisms should be substituted for the usual slit, and supplied him with a plan by which either one of the three could be slipped into position for use. Subsequently, when I had it in my possession and tested it by examining the continuous spectrum of various solutions, I found the result, however, by no means satisfactory: I do not think there is any other word by which to describe it than failure. The bands across the spectrum were far worse than those from the dirtiest slit ever seen. Trying it again for the sodium line, I found it sharp and bright, though only single on account of the much diminished magnifying power, and I was reluctantly compelled to acknowledge that, good as it might be for bright line spectra, it had failed for continuous spectra.

The next question to decide was, whether the failure was due to an optical or mechanical cause, whether the theory was right, but the practical working out of it imperfect: I was disposed to believe it was the latter, and not being deeply versed in optics, I could only satisfy my own mind by further experiments.

I examined with a lens the edges of the linear surfaces, if I may use such an expression, of the prisms, and found that they were not perfect, that there were minute depressions, tiny splinters of glass gone, which, though invisible to the naked eye, were, I believed, the cause of the mischief. I had them reground and repolished several times with varying results, which I need not describe. I had meditated from the first employing quartz as being harder and consequently more durable, but I wished to make use of glass if it were practicable. The next step was to grind three quartz prisms with great care and attention, and the result proved, I think, fairly satisfactory, and are now submitted for your verdict.

It will, I think, be evident to everyone that if such a prism as I have described can without disadvantage be substituted for the usual slit, the narrow face of the prism may be very readily cleaned from any dust which may settle on it, by withdrawing the fitting and gently wiping it with a handkerchief or other suitably soft material. For want of a more expressive term, I have called this arrangement a "solid slit."

It would perhaps be hazardous to state that it is quite a new feature in glass grinding to produce a surface of almost no width with nevertheless sharp edges, but at any rate I believe it is new, and there can be no doubt that with more practice the workmen would become more proficient in the production of such surfaces; upon these, of course, the whole value of the arrangement rests. It is very pleasant to believe our own designs perfect, our ideas right, and our geese swans; but if you do not accept this which is the main feature of my instrument, some of the minor alterations, which I will lay before you as briefly as possible, may meet with some approval.

Presuming that this prism arrangement is condemned, you will see that I have here a slit arrangement, which slides in the same dovetail as the prism fitting. This is opened and closed by a micrometer screw from the outside, the head of which is divided for registration if necessary, the edge of the fitting carries an index, which slides past a silvered scale divided into 100ths of an inch. A better arrangement would have been to have a vernier instead of an index, and the readings then would have given thousandths, and the position of absorption bands or lines obtained by means of the bright spot above the direct vision prisms. There could be no more easy method, I think, for cleaning the jaws of a slit than by this method of making the fitting removable from the side.

It is manifest that the distance between bands at the opposite extremes of the spectrum may be more rapidly measured by this sliding movement than by numerous turns of a micrometer screw; such screw, I think, should only be used as a fine adjustment, and if it has such work thrown upon it as I have suggested, it would, I believe, be found to rapidly deteriorate. It may perhaps be argued that this sliding movement does not give such facility as a screw for accurately placing any line in exact juxtaposition with the point of the bright spot, but I feel sure that anyone would find this much easier than they might imagine, and that no one accustomed to the delicate manipulation of microscopic work would find the slightest inconvenience from this cause.

For micrometric purposes, however, I have adoped the method which has been for some time in use, i. e. the image of a photograph scale reflected from the upper surface of the top prism. This image passes through two collimating lenses to render the rays parallel, and can be focussed by a sliding movement of the lenses in an inner tube by means of two pins passing through slots: I have had the head of one of the pins made to screw on, so that when the right position is obtained, a slight turn of the head renders it immovable by clamping the inner tube. The photograph image may be moved in three directions; it may be placed across the top, bottom, or middle of the spectrum by rotating the cap, which carries the arm; and it may be rendered parallel to the spectrum by rotating the arm on its own axis—a clamp is furnished for fixing it in the latter position; thirdly, the image may be made to traverse the spectrum so as to get any division to correspond accurately with any band by a micrometer screw divided into 100ths of an inch, the head of the screw being also divided into 100ths gives a reading with a fixed index of 10,000ths. The scale reads in the same direction as the wave-lengths, that is, the highest numbers on the scale are found at that end of the spectrum which has the greatest number of wave-lengths.

For the comparison prism I have adopted one which has been in use a short time for astronomical purposes, that is, a right-angled prism with a slot ground in it; through this slot the light passes from the object on the stage of the microscope, whilst the portions of the prism on either side the slot transmit the light from the object on the comparison stage of the spectroscope. The effect of this is that the spectrum is divided into three parts, the upper and lower of which are the same, if the aperture in the comparison stage is covered by one object; but by a proper arrangement of two objects on the comparison stage, it is quite easy to display three different spectra at the same time; I do not, however, think that there is much practical advantage to be gained by so using three spectra. But I think in the case of two spectra but slightly different from each other, in the position of their lines, two comparisons are better than one. It is as though you made two observations at the same time.

The face of the prism from which the reflection is obtained, is covered externally with a plate of very thin sheet copper, the surface of which is blackened. The comparison prism is moved into or withdrawn from position by the fitting to which it is attached, sliding in brass dovetail grooves; this, I think, is more steady than the usual method of mounting it on a cylindrical rod;

there are four screws in the brass angle piece, connecting the prism with the slide, by which adjustment in two directions may be obtained; one renders the edge of the prism parallel with the slit, and the other renders the base of the prism parallel with the internal platform of the instrument.

Quite recently another method has been used in comparing spectra together, and I have within the last week made this the last addition to my instrument. Instead of having the spectra one above the other, in this arrangement they are actually superposed so that the whole of the field is occupied by each of the two, or by withdrawing the reflector a little, one half the field displays the spectrum from the stage of the microscope, and the other half this spectrum combined with that from the comparison stage.

This result is obtained in the most simple manner. To the end of the prism is cemented a small bit of glass with parallel surfaces in such a way that it forms, as it were, a continuation of the hypothenuse of the triangle of the comparison prism. It will be seen at once that it acts precisely in the same way as the glass in Dr. Beale's neutral tint reflector; some of the rays from the stage of the microscope pass through, and some of the rays from the comparison stage are reflected at right angles, and so join the path of the former.

The comparison stage is, I think, a much better form than the one in ordinary use; it consists of a flat plate with two hard white metal springs, beneath which the usual microscopic slide may be readily inserted, or in the same manner the tube carrier. This consists of a strip of brass, to which two curved springs are attached for holding in position the tubes in which liquids for spectroscopic examination are generally sealed.

To save the expense of a second spectroscope, I had an additional tube made with an adjustable slit to take the same direct vision prisms, the whole closing in a case for the pocket, which is all that is required for the preliminary examination of many objects, or to ascertain the presence of certain absorption lines in the solar spectrum caused by vapour in the atmosphere, which, according to Professor Piazzi Smyth,* is a far more delicate means of foretelling rain than the variations of the barometer.

I cannot conclude without expressing my indebtedness in these matters to Mr. Hilger for the readiness with which he carried out my suggestions, and for the practical hints he has given me; but, above all, for his kindness in placing his valuable collection of prisms at my disposal, and his permission to make use of his workshop and tools for any experiments I might wish to undertake.

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* 'Astronomical Register,' Sept. 1877; 'Journal of the Scottish Meteorological Society,' vol. v. p. 84.

NOTES AND MEMORANDA.

The Gemmiparous and Fissiparous Reproduction of the Noctilucæ (*Noctiluca miliaris*, Suriray).—I sum up in these few lines the following facts, not hitherto pointed out, or imperfectly known, which I shall elsewhere describe in detail with others already observed, in a memoir about to be published.

The disappearance of the tentacle, of the basilar tooth, of the flagellum, and of the infundibular furrow-like depression of the Noctilucæ before their reproduction, has been noticed by Brightwell (1857), as well as by Cienkowski (1871). I have proved that this disappearance is constant, and not accidental before fission, and that it takes place by atrophy properly so called, and not by retraction of the tentacle into the interior of the body. I have besides been able to follow the phases of the obliteration of the buccal slit, as the precursory phenomenon of gemmation. Before fission, this obliteration does not take place. The flagellum and the tentacle only fall off.

The buccal obliteration brings the Noctilucæ to the condition of a *cell* properly so called, closed on all sides, spherical, provided with a proper wall, represented by the envelope of the animal, and with well-known sarcodic contents, with a nucleus without nucleolus, also spherical. But there is here nothing to be compared with the encystment preceding the reproduction of different infusoria (*Euglenæ*, &c.).

Far from disappearing before the formation of the gemmæ, as has been said and figured by Cienkowski, the nucleus of these *unicellular adult* animals of ·3 mm. to 6 mm. diameter plays a direct and important part in the constitution of the contents of each gemma, as also does the yellowish substance of the cellular body which surrounds it; the cellular wall of the animal rises in a conoidal projection to form directly that of each gemma.

One individual with another, there are produced from 256 to 512 gemmæ, by gradual bisegmentation of the nucleus and of the cellular body, with a corresponding production of as many projections or gemmæ of the cell-wall, as fills one of the nucleo-cellular segments resulting from this bisegmentation. The total duration of these phenomena is from ten to twelve hours in a temperature of 12° to 18° in April and May.

The following are the phases of each division of the nucleus in this segmentation: it is lengthened into a cylinder, blunt at each end, and becomes very finely granulated, instead of remaining homogeneous. Immediately after, it becomes very finely striated longitudinally; the striæ are distinct, and evidently result from the juxtaposition of very thin colourless filaments, which compression shows to be soft and flexible. This fibrillar production, following the greater axis of the nucleus, is a constant fact in the fission of the nucleus of plants and animals, as Auerbach, Strasbürger, Bütschli, and E. Van Beneden have successively proved. About ten minutes later, the two extremities of the nucleus which had remained granulated, become spherical, whilst continuing united to one another by the bundle or little band of fibrillæ just formed. These two extremities thus constitute two spherical nuclei, finely granulated, between which exists the little band of fibrillæ whose extremities remain in continuity with these new nuclei. Gradually the little band of fibrillæ becomes attenuated towards the middle of its length, as if it were drawn out, and folds up more or less on itself, in such a way as to bring the two nuclei nearer to each other. This attenuation soon leads to the rupture of the continuity of the fibrillæ, of which each half then gradually withdraws into that one of the two new nuclei to which it had remained attached by one end. The bisegmentation is thus complete from an hour, to an hour and a half at most, after its commencement, presenting, in one individual with another, varieties of secondary importance as well as a few other peculiarities not pointed out here.

At the same time the layer of sarcodic substance (protoplasm), which is in immediate contact with the nucleus, is segmented without showing anything peculiar. But the whole of the sarcodic filaments, anastomosed into a network which is spread around the abovementioned layer, present some curious phases of segmentation. The extreme peripheric portion of this network is condensed into a thin yellowish layer or bordering, circumscribing that part of this reticulum which remains interposed between this homogeneous bordering and the equally homogeneous layer in contact with the nucleus. The whole contracts itself "*en bissac*" with a wrinkling of the surface, simulating torsion of the sarcodic substance, at the level of the constriction of the nucleus which precedes its division. The contraction of this "*bissac*" increases and culminates in a complete separation or segmentation of the sarcodic substance, which ends a few minutes after the completion of the nuclear fission. Afterwards, the substance forming a peripheral bordering to the reticulum, gradually approaches the perinuclear homologous layer (in consequence of the contraction of the intermediate network itself) until the latter disappears and the whole is blended into a yellowish, homogeneous, cellular body, with an undulating surface, lodged in a projection, corresponding to a gemma, of the wall of the body of the parent animal.

That is the case until the end of this double formation by simultaneous segmentation and gemmation, associated together in the gemmiparous reproduction of the Noctilucæ. The wall of each gemma and its cellular contents contract at their point of continuity with their homologues of the unicellular parent, and separate from them when the length of each is reduced to an average of ·018 mm., that is to say, when their number is either 256 or 512. They are so many new unicellular individuals like the one which generates them (to die afterwards), and which from the time of their ulterior evolutionary growth, always remain unicellular. At least no evolutionary phase higher than the tentaculated form has up to the present time been observed.

Before the gemmæ are completely separated from the parent and swim freely, a flagellum six or seven times their length is developed on their plane surface (the other being rounded), nearer to their blunt extremity (which is still adherent to the point of gemmation), than to the other end. This extremity is always foremost when the freed gemma swims upon its plane surface propelled by the undulations of the flagellum which trails behind it. One or two pulsatile vacuoles or vesicles of ·004 mm. diameter are seen in the cellular body of each gemma between the plane surface and the nucleus. This vesicle is absent in the adult.

No observer has been able up to the present to follow the evolutions of Noctilucæ from the gemma state up to that of the adult individual. It is not yet known whether the flagellum of the gemma from ·10 mm. to ·12 mm. in length remains like the flagellum of the adult, which is only ·06 mm. to ·07 mm. long. The smallest Noctilucæ which I have seen were of ·15 mm. diameter, spherical, without mouth or infundibular depression, and with neither flagellum nor tentacle. I have followed the formation of the mouth at the level of the nucleated cellular body adherent to the internal face of their wall. It begins by a linear wrinkle of the latter, which is thickened a little on each side of this fold by the production of two or three mammillated projections. This thickening becomes gradually yellowish, and takes the form of the lips of the buccal slit in the adult. These phenomena last about three-quarters of an hour, after which the lips open a little from time to time. Then begins the formation of the infundibular depression and of the rectilinear dorsal fold, as well as that of the tentacle. That of the flagellum only takes place after the complete development of this latter organ.

Let us note that some Noctilucæ are found scarcely larger than the greater number of the others which are anatomically double, that is to say, provided with two cellular bodies, with two alternate buccal slits, each accompanied with corresponding tentacle and flagellum. It is probable that they proceed from some gemma in which the fission raising their number from 128 to 256, or from 256 to 512, has failed, whilst it took place in the others; a gemma which nevertheless has continued to develop like the others.

The fission of the Noctilucæ has been pointed out by M. de Quatrefages (1850), and by Krohn (1852), who has seen that it begins by the fission of the nucleus, since better studied by Brightwell. The fission of the nucleus presents the same phases as at the time of its first division in the cases of gemmiparity. The total division of the Noctiluca takes place in such a manner that, once complete, each of the two new individuals has a buccal slit, in which one of the lips has grown from one of those of the buccal slit of its generator. A tentacle is developed on the side of the mouth of each new Noctiluca from the end of the total fission, or immediately after the separation of the two new individuals. It is about an hour before the freed organ begins its movements.

In all cases, the production of the tentacle begins by the formation of a short prolongation of the yellowish substance of the cellular body which raises the tegument near one of the lips of the buccal slit, showing itself a little. Below this prolongation and in continuity with it, a second is raised, conoidal at first, and gradually taking the form of a little band folded into a loop upon itself. The convex part of the angle projects more and more outside the body and becomes wider. One of its parts, which is narrower than the other, soon disengages its extremity from below the base represented by the first prolongation of the cellular body. From the time of this disengagement the little band, more or less straightened, has the general form of the tentacle and moves by slow undulations and distortions. At first yellowish, like the substance of the cellular body from which it is derived, in a few hours it becomes greyish and striated. It is after its formation that the infundibular depression of each new individual and the flagellum which accompanies it are formed.

The movements of the tentacle always remain slow and continuous, as if they were due to sarcodic contractions, whilst those of the flagellum take place alternatively by inflections and undulations, either wide or very short, slow or extremely rapid, then simulating a true vibratory movement, and with periods of inaction of irregular duration. Both these modes of activity as well as the sarcodic contractions, which are always slow, of the internal filaments of the Noctilucæ, are not in any way modified by induced currents, even powerful ones, nor by the making and breaking of the continuous currents. M. Cadiat and I have proved that such is also the case with the body, the pedicle, the cilia, and the pulsatile vesicle of the Vorticellæ, and for the homologous parts of the other Infusoria and Amœbæ, as long as the water and its salts are not decomposed. When this decomposition takes place under the influence of continuous currents these different movements, quickened for some minutes, cease at the same time that the animal dies.*

The Functions of Leaves. Part played by the Stomata in the Exhalation and Inhalation of Aqueous Vapours by the Leaves.—The part played by the stomata in exhalation by the leaves may be deduced *a priori* from the permanently open state of their ostioles, which are thus always ready to allow the issue of the vapours formed in the intercellular passages, from which they pass into the sub-stomatic air-chambers. In order to show that the vapours exhaled do really follow this course, I have tried to make them act, immediately on leaving the leaf surface, on sensitive hygrometric papers on which they would make an impression at the points of issue, so as to show exactly the position of the latter.

Of the various hygrometric papers which are available for this purpose, that which has seemed to me the best has its sensitive layer formed by a mixture of perchloride of iron and chloride of palladium, obtained photo-chemically. Of a yellowish white tint whilst dry, it passes into black by darker and darker tints, in proportion as it becomes damper, and when it has received a hygrometric impression, it is easily fixed by simple washing in a solution of perchloride of iron.

When we wish to apply it to the study of the foliar exhalation, a fold is made in the paper, into which is introduced and retained by

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* M. Ch. Robin, in 'Comptes Rendus,' vol lxxxvi. p. 1482.

means of a slight pressure, the limb of a leaf, which remains attached to the living plant, and which only imprints hygrometrically those parts of its surface at which normally vapours are emitted.

It is, moreover, to the vapours emitted, and not to the reactions of contact, that the impressions thus produced are due, for they are equally formed through double folds of porous paper.

With leaves of three morphological types they present the following characters:—

1st. Leaves with stomata on the lower surface only. When these leaves have completed their development, the impression of their inferior surface, which appears distinctly from the first moments of the application of the blade, attains in a few minutes its maximum vigour; and, during the short interval of time sufficient for its formation, the upper surface does not make a sensible impression. As, however, it ultimately produces an impression on the hygrometric paper, there can be no doubt as to its exhaling power; but it is always very weak, and may be practically disregarded, in comparison with that of the inferior surface.

In the impression formed by the latter, the venation is marked out, in white, on a more or less tinted ground which corresponds to the parenchymatous surfaces. These surfaces thus emit more aqueous vapours than those of the veins, although their cuticle is thicker and more waxy, and covers tissues less penetrated with moisture: their excess of emission can therefore only arise from the diffusion of the internal vapours through the orifices of their numerous stomata. It is especially in the exhalation of these leaves, taken at different phases of their development, that it is seen in what degree the activity of this function depends on the part which the stomata take in its accomplishment.

So long as these little organs are not formed, the two leaf faces exhale almost in the same manner; but in proportion as they appear and multiply on the inferior face, the exhalation of this face increases rapidly, whilst that of the superior face decreases in consequence of the thickening of the cuticle and the strengthening of its waxy deposit.

When the leaf is completely developed, the superior face plays only a very small part, which may generally be neglected, in the total exhalation, because it may be deprived of its evaporative property, by covering it with an impermeable varnish, without the leaf appearing to suffer. This same leaf, on the contrary, soon withers and falls, or rots *in situ*, when it is rendered impermeable on its inferior face.

2nd. Leaves with stomata on both surfaces. In those of these leaves which belong to the group of dicotyledonous plants, the inferior face, having the stomata in larger number and evenly distributed, gives impressions evenly shaded everywhere, on which the veins are marked out in white. The impression of the superior face, at once paler and unevenly tinted, shows thereby the relative rarity of the stomata and their uneven distribution, which it reproduces faithfully.

In the leaves of monocotyledonous plants, the advantage, in regard to the number of stomata, is sometimes with the superior face, and it is that which then gives the most strongly tinted impression. In this impression, as in that of the inferior face, the stomata are shown, arranged in a linear series parallel to the veins.

3rd. Leaves with stomata on the superior surface only. The superior face alone gives an impression, although its cuticle is much thicker and much more strongly coated with wax than that of the inferior face.

The conclusion to be derived from these facts is the following: the leaves can emit aqueous vapours, both by the cuticle and by the stomata; in proportion as they advance in their development, the exhaling power of the cuticle, which goes on diminishing, tends to become inappreciable; when they are completely developed, it is by the stomatic orifices that the foliar exhalation takes place normally.

The activity of the exhalation increases with the richness of the tissues in chlorophyll.

The exhalation of the aqueous vapours is equally produced by the stomata also.*

Staining for the Central Nerve System.—In his 'Manual of Human Anatomy,' Henlé mentions a method of staining the central nerve system originated by Merkel, and which consists in placing the section first for one to two minutes in chloride of palladium (1 : 300–600), and then (after being washed) in Gerlach-Clarke's carmine solution. In the course of my investigations, however, I found that a pigment recently produced by Dr. Witte, produced far more beautiful results with this method than the carmine solution. This substance is the picro-carminate of soda. The staining is very effective; the ganglion-cells and the axis-cylinder are deep red, whilst the white substance of Schwann becomes a strong yellow; the red, moreover, is a very pleasing soft carmine-red, and the yellow that of picric acid. Ordinary picro-carmine does not yield nearly such beautiful results.

As regards the process, it is best to use cold saturated solutions of the picro-carminate of soda, as this on the whole only stains slightly. After the preparation has been let lie for about one to two minutes in the palladium solution, and then been rinsed, it is let remain in the pigment solution some eight to ten minutes. Then varnished over. It must be admitted that a darkening of the palladium staining frequently occurs later on, whereby the preparations suffer if not sheltered from the light.

The process is further very suitable for staining isolated ganglion-cells, and this is best done by using Ranvier's alcohol. I confine myself to the use of Ranvier's recipe, at least as regards the central nerve system; his alcohol has done me better service than the maceration solution recommended by Deilers, and the carbolic acid lately recommended by Eichhorst in the 'Centralblatt.' If into a moderate quantity (so much that the preparations can lie easily in it) of Ranvier's alcohol, fresh spinal cord of the calf or ox be laid, in pieces of about half a centimetre thickness, for some days in a well-closed glass, you

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* M. Merget, in 'Comptes Rendus,' vol. lxxxvii. p. 293.

can afterwards, by shaking small pieces of the grey substance in a little water in a reagent-glass, obtain very superior isolated ganglion-cells. When you think that it has been shaken enough, put a little glycerine to the water, and some drops of the concentrated solution of the picro-carminate of soda. Then let the glass remain undisturbed for a day or two. After that time the ganglion-cells, by reason of their greater specific gravity, will have sunk either to the bottom of the glass or will be found in the lower strata of the water. What swims on the top is generally only shreds of connective tissue, in which there may be a ganglion-cell here and there. Generally the upper portion of the fluid may now be poured off without much being lost. If much fluid is left, repeat the process after some time. The small remaining quantity of diluted red-coloured glycerine with the cells and shreds of connective tissue is then shaken in a small watch-glass, a few drops of glycerine added, and then placed in a sulphuric acid drying apparatus; at the end of two days the whole of the water has generally evaporated, and the shreds of tissues and cells lie (deeply stained) in glycerine pretty free from water, in which they may be kept as long as is wished. Gradually the stain seems to be attracted more and more to the tissue elements, and the fluid becomes almost colourless. In the watch-glass may now be seen under the microscope the finest ganglion-cells stained deep red, and thereby easily to be discovered amongst the shreds of connective tissue, which are only weakly stained. The ganglion-cells cannot be fished out with a needle under a dissecting microscope and transferred to a mounting glass for mounting, as the numerous continuations almost always fix them. It is far better to place a drop of the fluid, in which there will generally be some cells, on the mounting glass, and then detach by means of a needle under the dissecting microscope the useless shreds of connective tissue, if possible without touching the cells. It is surprising how much easier the ganglion-cells are found after the staining, and how many more are seen. The large cells may be recognized with the naked eye. As any transfer of the ganglion-cells, however carefully made, always does some damage, the plano-concave slips, such as frequently accompanied the older microscopes, are best suited for the purpose of observation. In this case, however, only the weaker systems can be employed. As the cells will keep for any time in the glycerine, this method is well suited to provide a stock for a course.

In other respects, picro-carminate of soda is not suited, according to my experience, to replace picro-carmine, as it possesses too weak a power of staining.*

"*Ultimate Limit of Vision.*"—Dr. Fripp, of Bristol, the well-known translator of the papers of Professor Abbe and Helmholtz on the theory of microscopic vision, and the author of several valuable papers on that subject in the 'Proceedings of the Bristol Naturalists' Society,' writes as follows in regard to a suggestion made to him that Mr. Dallinger's measurement of the flagellum of *Bacterium termo,* the

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* Dr. Schiefferdecker, in 'Archiv f. Mik. Anat.,' vol. xv. p. 38.

$\frac{1}{200000}$ of an inch in diameter, controverted, more or less, the views propounded by the two Professors:—

"Mr. Dallinger's paper is interesting. To get sight of a flagellum $\frac{1}{200000}$ inch diameter in the microscope implies very clever manipulation. Its measurement was, however, indirectly achieved by finding the ratio of the $\frac{5}{1}$ magnified flagellum to the actually measured diameter of the body.

There is no question of resolving a structure here, and I entirely fail to see that the subject has anything to do with the theories of Helmholtz and Abbe. It is a question of physiological not microscopical limits of sight.

Look at a fixed star, or at a white-hot platinum wire 80 feet from the observer in a lecture theatre: you *see* it, that is, an impression on the retina is made, but you cannot distinguish its outlines, features, or structure.

So, an isolated line or particle may be *seen* under clever manipulation, in which management of light is everything.

But if Mr. Dallinger had placed half-a-dozen of the flagella close together with interspaces equal to their own thickness, and then found that he could distinguish them separately, such a fact would militate against Helmholtz's statements.

Helmholtz demonstrates (and embodies his demonstration in a formula) that there is a calculable interspace between finely drawn lines, which, when these lines are looked at through a microscope, still allows them to be *separately visible* to the eye, and that if the lines are closer together than this computed interspace, diffraction occurs and wipes out the actual state of things, replacing it with a diffraction spectrum. But Helmholtz does not apply his formula to measure *distinctness of definition*, which is an English misreading of the facts and statements.

If we look at a fine network of white-hot platinum wires, should we see *each* single wire distinctly because we readily see *one* such when isolated?

The question of resolution of structure is a very different one from that of seeing a single fine line. Volkman has long ago shown what *acuteness* of vision means, and he has outdone the particular case of Mr. Dallinger in seeing a fine line against the light, but of course not in the microscope.

Abbe has not, in any optical essay that I have seen, said a word about the possible or impossible limit of vision in the physiological sense, though many other writers have.

The whole drift of Professor Abbe's theory of the microscopic image seems to me to be misunderstood by those who suppose that it applies to some given standard of acute vision. But it is not with visual sense, or with the capacity of the eye, that he deals. It is with the optical capacity pertaining to the microscope of *presenting to the eye* distinct and distinguishable details. And the factors which he had to consider are—1. The peculiarities attendant upon the optical outspread of the microscopic image by presenting it under large angular divergence. 2. The peculiarities which render geometric definition of an object (point for point) difficult of attainment. 3. The function of angular aperture of the objective. And he maintains that this latter part of the subject opens an entirely new aspect of the theory of the microscope which has been hitherto ignored.

Whether a point or line of light, or shadow, can be *seen*, has absolutely nothing in common with the question whether that which is seen well (and which is, of course, the optical expression of *some* fact) as an isolated object, can be equally well seen when in close apposition with a series of similar and equally minute objects. We cannot longer continue to interpret on the strength of an hypothesis which has been disproved.

In the grosser cases of bad definition nobody pretends that dispersion circles adequately represent the object under view, but neither could anyone charge upon this explanation (dispersion) that it proved or implied any 'limitation of visual power.'

And, in considering the subtle phenomena conditioned by the use of objectives constructed with large aperture, if it be proved that their optical function labours under various physical disabilities—among others, for instance, that rays of light may so interfere as to render void instead of presenting to the eye the actual structure from which they arise—this is surely no reason for confounding the *fact* that a structure cannot be seen under these given conditions, with the inference that an 'ultimate limit of vision' has been found for all other objects and under all other circumstances. It seems more natural to believe that minute particles in close juxtaposition shall, when viewed through a microscope, produce such interference of rays as to annul or distort the microscopic image; although the same, or even much smaller particles, when isolated (not interfering with each other) may be distinguished.

The flagellum was *seen*, not *resolved*—if the term 'resolution' has any meaning!

Abbe does assert that what has been, or can be resolved by a $\frac{1}{25}$, $\frac{1}{50}$, or $\frac{1}{80}$ inch objective can be as clearly resolved by a $\frac{1}{12}$ or $\frac{1}{16}$ immersion lens, because the additional amplification helps at furthest to enlarge the image, but it is an empty amplification. Take Dr. Woodward's photographs of Diatomaceæ with a $\frac{1}{16}$. Have the possessors of $\frac{1}{80}$, $\frac{1}{50}$, or $\frac{1}{25}$ objectives seen anything more or newer than Mr. Stephenson's *Pleurosigma* drawing from $\frac{1}{8}$-inch immersion?

Professor Abbe's whole writings sufficiently prove that he has kept to the subject of geometric definition of images in the microscope, diffraction images, distribution of light in the microscopic image, illumination, &c.; and these are so bound up together, and the theory of the microscope and the theory of illumination are so interconnected, that neither could be understood without the other.

But the question of the minutest dot or line which can be seen is simply one of physiology; thus, what is the least difference of light and shadow disposed in line or as isolated lights or shadows (white on dark or dark on white) which, thrown on the retina, can excite special nerve sensation, i. e. sight? I exclude colour, because differences of colour are more perceptible than grades of more or less white light.

And as a mere triumph of illumination and manipulation, the glimpsing a monad flagellum deserves attention. But what is the value (I mean of course the *microscopic* not the *anatomical* value, with which I am not dealing) of the discovery of an indistinct, shadowy line, without any interior, so to speak, to 'resolve'?"[*]

The Animal of Millepora alcicornis.—The attention of zoologists was called to the relations of Millepora by the announcement of Agassiz, in 1858, that "Millepora is not an Actinoid Polyp, but a genuine Hydroid, allied to Hydractinia." Professor Agassiz figured the animals as seen by him, in his 'Contributions to the Natural History of the United States,' vol. iii. p. 61. On the evidence afforded by a single observation of Millepora, he proposed to transfer to the Acalephæ not only that genus, but all the Madreporaria Tabulata of Milne-Edwards. Professor Verrill has shown that the latter inference cannot be accepted, and that the Madreporaria Tabulata form an artificial and quite heterogeneous assemblage. There has been much difference of opinion as to the soundness of Agassiz's conclusion in regard to Millepora itself, and the extreme shyness of the animals has rendered it impossible to accumulate numerous observations. A paper by General Nelson and P. Martin Duncan[†] contains figures of the animals of *Millepora alcicornis* as observed by the former author while stationed at Bermuda many years ago. The figures differ from those of Agassiz in arranging the tentacles regularly in whorls of four, and the authors conclude that Millepora is probably an Alcyonarian. The arrangement of tentacles is certainly quite unusual in the Alcyonaria, admitting the correctness of General Nelson's figures. In November, 1875, a paper by Mr. Moseley, of the 'Challenger' expedition, was read before the Royal Society,[‡] in which the author reported observations on Millepora at Bermuda and elsewhere. The observations seem to have been quite unsatisfactory, and the author at that time ventured no conclusion from them. He was, however, more fortunate at Tahiti; and his paper read before the Royal Society in April, 1876,[§] gives the results of a more complete and satisfactory series of observations on the genus in question than has been made by any other author. His conclusions agree substantially with those of Agassiz.

In the winter of 1876–7 the writer spent some weeks in Bermuda, residing for a part of the time at Flats Village, on the shore of Harrington Sound. The abundance of Millepora in the shallow water of that beautiful lagoon afforded excellent opportunity for an investigation of the animals. In this work the writer was favoured with the kind assistance of Mr. G. Brown Goode, of the Smithsonian Institution. Our experience enabled us to appreciate the difficulty which observers have always found in the extreme shyness of the animals. Great care was taken, in collecting the animals, to avoid

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[*] It is, of course, obvious that with lines $\frac{1}{200000}$ of an inch in width, and interspaces of the same dimensions, there would be only 100,000 lines in an inch of space.

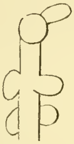
[†] 'Ann. and Mag. Nat. Hist.,' xvii. 354.

[‡] 'Phil. Trans.,' clxvi. 91.

[§] Ibid., clxvii. 117.

subjecting them to any more of a shock than was necessary. In accordance with a suggestion of Professor Verrill, we were careful not to have the specimens out of water for an instant either in collecting them or in the subsequent manipulation. Specimens were collected at various hours of the day, and examined at about all hours of the day and night. Only once were we favoured with a sight of the zooids in expansion. Though that observation was far from being as satisfactory as could be desired, the writer has thought it might be worth while to give an account of it; for, on a subject so important and presenting such difficulties to every observer, every scrap of observation is probably worth saving.

The zooids which we saw in expansion showed generally a pretty regular whorl of tentacles at the summit. There seemed to be indications of a tendency to a grouping of the tentacles in one or more whorls below the one at the summit. But these lower whorls were not at all regularly developed, and in some cases the tentacles were scattered singly without any recognizable arrangement in successive whorls. Where an approximation to a whorled arrangement could be recognized, the number of tentacles in a whorl was generally four, but appeared to be sometimes three. As regards the arrangement of the tentacles, our observation is therefore substantially in agreement with those of Agassiz and Moseley. We feel very confident that the tentacles are not in uniform and regular whorls of four, as figured by Nelson and Duncan.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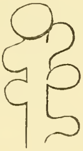
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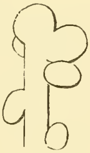
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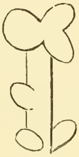
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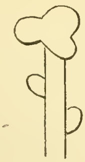
The accompanying figures, 1 to 20, represent the outlines of several zooids in the various positions in which they chanced to present themselves. The drawings were made hastily while the specimens were under examination. It is needless to remark that they make no pretention to any artistic character. Whatever value they may have arises from the fact of a conscientious endeavour to draw exactly the outlines which were seen, not a line being added hypothetically or inferentially.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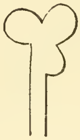
Figs. 1 to 16 represent zooids seen more or less nearly in profile; Figs. 17 to 20, zooids seen from above. Figs. 5, 6, 8, 14, 15, were drawn by Mr. Goode; the remainder by the writer. The drawings testify to the entire agreement between the two observers. The zooids seen by us appear to have been of the mouthless kind. Moseley has noticed the fact that these expand much more readily than the others. Our observations were made partly with a 2-inch, but chiefly with a 1-inch objective.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Some attempts were made to study the zooids by means of decalcified specimens, previously treated with picric acid and alcohol; a preliminary treatment with picric acid and subsequent removal to alcohol having been shown by experiments undertaken by members of the United States Fish Commission in 1874, to be remarkably effective in preserving the delicate tissues of Hydrozoa. We did not succeed in obtaining by this means any zooids in satisfactory condition. The specimens, however, prepared as above stated, and subsequently mounted in glycerine jelly, show well some details of structure, particularly the lasso-cells with extraordinarily long threads, figured by Moseley.* Moseley's figures of a lasso-cell from *Millepora nodosa* illustrates well the character of those in *Millepora alcicornis*, though in the latter the spinous portion is somewhat nearer the base of the thread. The length of the thread in the largest of our specimens is about ·027 inch.†

Liberation of the Zoospores, Antherozoids, &c., in the Lower Plants.—M. Cornu has succeeded in producing at will the emission of the antherozoids of *Polystichium Filix-Mas*, of which the prothallia had been kept at the surrounding temperature during the cold season. In March, one of the prothallia, having been removed and placed in a drop of the liquid from the same flask, to be examined under the microscope, emitted a great number of agile antherozoids; the same thing happened in June. Nothing was changed in the conditions of

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* 'Phil. Trans.,' clxvii. pl. ii. fig. 1.

† Mr. Wm. North Rice, in 'American Journal of Science and Arts,' vol. xvi. p. 180.

existence of the antheridia—medium, light, temperature—only one new influence could have affected them, that of the air. M. Cornu reported several years ago an analogous fact* amongst the aquatic fungi. The result of his observations is, that the conditions sufficient to allow of the complete and definitive development of the antheridia and sporangia may be insufficient to allow of the dehiscence. This dehiscence is not a violent result of endosmose, since it remains suspended during long intervals, the prothallus being immersed in a liquid; it is not determined by the variations of temperature or the intensity of light, for no change of this nature was produced in the experiment. If the zoospores of the Algæ escape in the early hours of clear days in spring or summer, it is because the water which contains them becomes richer in oxygen under the action of the chlorophyll when exposed to the light.

We are thus led to conclude that the aeration of the water gives to the already formed agile corpuscles a sufficient energy to enable them to free themselves. Heat produces analogous effects. The *Œdogonia*, which, placed in a room at 7 or 8 degrees, do not emit their spores, produce them abundantly when they are transferred to an atmosphere of 16 or 18 degrees.

M. Cornu thinks that air or heat acts by increasing the activity of the plasmatic movements, and that it is in consequence of an activity natural to the protoplasm—which is destitute of membrane, and, in spite of that, capable of utilizing oxygen—that the wall of the zoosporangium is perforated.†

Œcistes pilula.—In the 'Monthly Microscopical Journal,'‡ Mr. C. Cubitt refers to this species under the name of *Melicerta pilula*, which he gave to it "from the fact that she fortifies the gelatinous basis of the theca with her own excremental pilules." Mr. A. W. Wills, who has very recently had opportunities of observing the rotifer, says:—

"Mr. Cubitt's description of the singular habit of this animal is quite correct, but he does not appear to have observed the precise manner in which the remarkable operation is performed, from which it derives its name. It is self-evident that only a minority of the excrementary pellets discharged by the creature can be required or used to fortify its theca. The larger part are whirled away from the vicinity of the animal, in the manner familiar to all who have observed the thecated Rotifers or the fresh-water Polyzoa; but those which are utilized for building purposes are ejected between the rotifer and its tube or theca, and received under the lower margin of the ciliated trochus, where they remain for a few seconds, as if the animal were making sure of its proper hold, and then, by a sudden retraction of its body, it dabs the pellet into a proper position on the margin of the theca, and instantly resumes its usual condition. The amount and regularity of the pellets with which the tube is fortified varies very much. One finds occasionally an individual in which they

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* See his "Monographie des Saprolegniées" ('Ann. Sc. Nat.,' 1872, vol. xv. p. 117).

† 'Bull. de la Soc. Bot. de France,' vol. xv. p. 39. (From 'Comptes Rendus.')

‡ Vol. viii. p. 5.

are so few and irregular, as only to suffice for the identification of the species. Regular feeding with water containing abundant food produces a corresponding increase in their number and regularity, and a supply of carmine and indigo on alternate days is followed by the deposition of very regular alternate layers of red and blue courses on the outside of the tube. . . .

My specimens produced abundant ova, which were formed in the usual manner in the ovary, and thence extruded into the space between the animal and its theca, and deposited upon the lower part of the foot, as is customary with this division of the Rotifera. I have not yet observed their development, nor, although I have examined a large number of specimens, have I yet been fortunate enough to see the male of this species."*

Cutaneous Glands.—On page 261 of 'Huxley and Martin's Elementary Biology,' in treating of the skin, it is stated that the mouths of the cutaneous glands are seen as claer round spots, although their openings are really tri-radiate. No directions are given for demonstrating that appearance, but it may be done very nicely by putting a bit of skin from a frog's back or side into Müller's fluid one part, water four parts (any weak solution of a chromium compound would do very well), for two or three days. The layers of the epidermis come apart, and the external layer shows perfectly the tri-radiate openings of the glands. If this layer be coloured in carmine or picro-carmine, it makes a very pretty and instructive object; for it not only shows the mouths of the glands, but the large flat nucleated epidermal cells. Professor H. H. Straight, of the Oswego Normal School, says, "If a live frog be wiped dry with a cloth, and then put into water overnight, the external layer of epidermis comes off very readily," that is, the frog has been made to cast its skin. By making use of this process the points mentioned above might be demonstrated without hurting the frog.†

"*Limits of Accuracy in Measurement with the Microscope.*"—A paper with this title, read at the Indianapolis Congress by Professor W. A. Rogers, concluded as follows:—

"I think we may safely draw the following conclusions from this investigation:

1. Two equally skilled observers can measure the same space within about $\frac{1}{300000}$ of an inch, if the space does not exceed $\frac{1}{500}$ of an inch. For a space of $\frac{1}{100}$ of an inch the deviation will probably amount to $\frac{1}{80000}$ of an inch, in case the measurements are made with an eye-piece or a filar micrometer.

2. The average deviation for accumulated errors, under similar conditions, is not far from $\frac{1}{50000}$ of an inch for eleven intervals. For a large number of intervals the deviation will be somewhat larger, but it will not be proportional to the number of intervals.

3. A single observer can obtain an agreement with a normal equation representing all the observed values as far as a solution by least

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* 'Midland Naturalist,' vol. i. p. 302.

† Mr. Gage, in 'American Quarterly Microscopical Journal,' vol. i. p. 72.

squares can represent them, within somewhat smaller limits than those obtained by comparing the results obtained by two different observers." *

"On the 9th October, Professor Rogers read a [the same ?] paper before the American Academy of Arts and Sciences at Boston, in which he stated that Professor E. A. Morley and himself independently measured 195 spaces, having a magnitude of about $\frac{1}{500}$ of an inch, each space, however, varying slightly from this value. The measures were made with a glass eye-piece micrometer, a Beck's spider-line micrometer, and with a screw attached to the sub-stage of the microscope. After the results were prepared for the press they were for the first time compared. It was found that the average difference between the results for a single space was 32 millionths of an inch, and the greatest difference was 12 millionths.† There were only four cases in which the difference amounted to one hundred-thousandth of an inch." ‡

The Influence of Repose and Motion in the Phenomena of Life.—I think I have succeeded in demonstrating the existence of a new condition necessary to the life of organized beings. It may be formulated thus: the development or the multiplication of the elements which constitute living beings requires a certain period of repose.

My experiments were practised on bacteria, § for the following reasons:—

1st. When once they are placed in favourable conditions of nutrition and temperature, they multiply in a more rapid manner than any other living being.

2nd. This multiplication is proved in a manner as simple as it is accurate.

3rd. Considering the smallness of the bacteria, and the elasticity which is generally attributed to them, the possibility of a mechanical lesion of these beings by the motion which is applied to them is reduced to a minimum.

My experiments were made in the following manner:—

I placed in several tubes of glass, specially constructed for this purpose, a liquid favourable to the multiplication of bacteria, ‖ and which contained a certain number of living ones. Then, some of these tubes were continually shaken, whilst the others, with the same contents and conditions of temperature, were left at rest.

These experiments showed that, in the liquid of the latter tubes,

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* 'American Journal of Microscopy,' vol. iii. p. 197.

† There would appear to be some error in these figures.

‡ 'Nature,' vol. xviii. p. 712.

§ These experiments, commenced in 1875 in the laboratory of Professor de Bary at Strasburg, have been continued in the laboratory of M. Claude Bernard, at the Museum of Natural History.

‖ In my experiments I have always employed the same nutritive liquid; it contained in a litre of distilled water:

10 grammes of tartrate of ammonia (neutral salt).
5 grammes of phosphate of potash (acid salt).
5 grammes of sulphate of magnesia.
½ a gramme of chloride of calcium.

the bacteria multiplied prodigiously; but, on the contrary, no sign of multiplication was observed in the other tubes.

To make the abundant multiplication of bacteria in the nutritive liquid evident, I followed the same process which I employed in 1872, and which is described in my researches on bacteria,* a process in which the prodigious multiplication of the bacteria was revealed by the turbidity and characteristic cloudiness of the nutritive liquid which at the commencement was colourless and transparent.†

Development of Lichens.—The second part of Stahl's 'Contribution to the Development-History of Lichens' has been published. It treats of the nature of the hymeneal gonidia. We find in the hymenium of *Dermatocarpon Schœreri*, crossing freely between the thecæ, globular gonidia which differ from those of the thallus by their still smaller size, and which are expelled from the perithecium at the same time as the ripe spores. When this simultaneous emission is made on a suitable substance, the spores germinate, and the tubes arising from their germination surround the hymeneal gonidia, which soon attain the dimensions of those of the thallus. We may then see in a short time the reproduction of *Dermatocarpon Schœreri* furnished with its characteristic thallus.

The baculiform hymeneal gonidia of the *Polyblastia rugulosa*, which agree in their characters with the free Algæ of the genus *Stichococcus*, have furnished the observer with phenomena identical with those of *Dermatocarpon*. A little species of *Thelidium*, not yet described, very often accompanies *Dermatocarpon*, and the gonidia of these lichens are specifically identical. If a cultivation experiment is so arranged as to bring the spores of the *Thelidium* into contact with the hymeneal gonidia of *Dermatocarpon* perfectly free of all mixture, we obtain, as the result of the experiment, the thallus of the *Thelidium* with its characteristic fructification. The same Alga which gives these gonidia, and which is, according to the author, a species of *Protococcus*, may consequently bring itself into relation with two different Ascomycetes, in order to form two lichens also different.‡

Microscopical Study of the Ashes of Leaves.—At the Indianapolis Congress Dr. R. H. Ward, of Troy, described the method by which leaf ashes may be prepared so as to preserve much of the structure of the leaf.

The books speak of the siliceous residue of the leaves of the grasses, but many other leaves are equally available; leaves of trees are generally used with more success than those of herbs, and they should be gathered late in the summer.

A piece of dry leaf is laid on a strip of platinum foil or thin mica, covered with mica or a cover-glass to prevent curling up, and carefully heated over an alcohol lamp or Bunsen burner until the organic matter is slowly burned out, and the mineral matter, or ash, remains

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* 'Beiträge zur Biologie d. Pflanzen,' by Professor F. Cohn, pp. 218 and 196. 1872.

† M. A. Howath, in 'Comptes Rendus,' vol. lxxxvi. p. 703.—See, for further details, my work presented to the Biological Society, January, 1878.

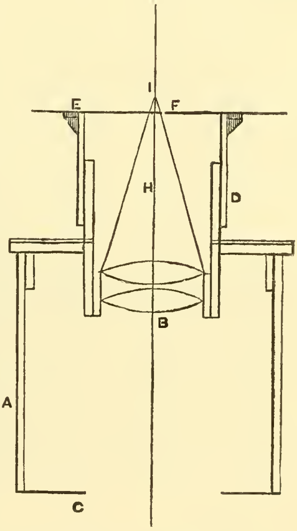
‡ 'Bull. de la Soc. Bot. de France,' vol. xxv. p. 32.

undisturbed. This is then dropped on to a slide wet with turpentine, and very carefully mounted in soft balsam. If slightly crushed in mounting, or containing a trace of carbon at some point, the value of the object is often increased.

These preparations can be made with great ease and rapidity, and show the construction of the parenchyma, veins, epidermis, stomates, and hairs, with great beauty and distinctness.

In this way was prepared a slide of leaf ashes which was recently sent through the circuits of the Postal Club, and which excited an unexpected amount of interest and correspondence.*

A New Device for Dark-Field Illumination.—I have been quite interested, lately, in some experiments connected with the subject of dark-ground illumination, and have worked out a device which brings out new and most interesting results: the accompanying diagram will illustrate its working.



Let A represent a sectional view of the tube of an eye-piece; B, a triple achromatic lens of 1-inch focus, and 30° aperture; C, the diaphragm; D, cap of the eye-piece sliding over the tube of the achromatic lens; E, a thin brass plate sliding between grooves in the top of the cap, having at the point F a small hole, of not more than $\frac{1}{20}$ of an inch in diameter; H, the cone of rays of the achromatic eye-lens, meeting at I.

Place the thin plate so that the hole F will be at the side, and as near the apex of the cone of rays as possible. It is quite evident that none of the light usually used by the eye will be allowed to pass to it, as it will be interrupted by the brass plate. By placing the eye at the hole F, and looking at a suitable object upon the stage of the microscope, a most wonderful sight will be seen. The object will be brilliantly shown upon a dark field. I would suggest its trial upon the diatom *Heliopelta*. It is not necessary to explain the principle of the device, as it will be quite evident to those familiar with optical work. By revolving the eye-piece in the body tube many curious changes in the appearance of the object will take place. In using oblique light it will be found best to place the hole on the opposite side of the cone of rays from the mirror. The arrangement can be used with the common eye-piece, but with an inferior result. The value of the device can be tested by making a hole in cardboard with a small pin, and holding it at its proper place over the eye-piece.†

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* 'American Naturalist,' vol. xii. p. 704.

† Prof. Wm. Lighton, in 'American Quarterly Microscopical Journal,' vol. i.

The Termination of the Nerves in the Striated Muscles.—The termination of the nerves in striated muscles has given rise, in recent times, to numerous researches, which, notwithstanding all the interest which they present, have not yet cast a complete light on this part of science. It was thought, for instance, that the termination of the sensitive nerves in the muscles had been discovered; but these results, due to defective researches, cannot be considered as correct. Moreover, all the efforts which have been made to find intermediate forms between the terminations in plates and the motor termination in the frog, have remained without success.

The process of colouring the nerves by means of chloride of gold, recently communicated by M. L. Ranvier,* having furnished me with an excellent and certain method for studying the nerve terminations, I have undertaken, with this double object, a series of researches, which have led me to some new results.

1st. The nervous fibres without myeline which are found in the thin muscles of the frog, as, for example, in the thoracic cutaneous muscle, and which had been regarded hitherto as sensitive fibres, do not belong to the muscle properly speaking, but to its aponeurosis. These fibres, arising from the intramuscular nerves, form in the aponeuroses a network of large meshes. Their terminations are identical with the nerve terminations which are found in the cornea.

It is evident from their microscopic structure, as well as from their anatomical relations, that these nerves of the aponeuroses ought to be considered as centripetal nerves, starting from the muscle. The necessity of admitting the existence of these nerves is insisted on in a work which I have recently published.

Nerve-fibres similar to those which I have just pointed out in the frog, are also met with in the aponeuroses of other animals.

2nd. I have found it quite impossible to prove in the dissociated muscles of the frog, and of some other species of animals (tortoise, triton, lizard, snake, and rabbit), the presence of nerve-fibres without myeline, other than those which belong to the vascular or aponeurotic nerves, and the presence of nerve terminations, other than the motor terminations.

3rd. I have, on the contrary, been able to find in several species of animals new forms of nerve terminations, which constitute intermediaries between the motor termination, as it is found in the frog, and the terminal plates.

I have proved the existence of terminations of this kind in the tortoise, the triton, the salamander, the lizard, and the snake. In the three first named, these terminations are the only ones which we are able to find, whilst in the snake and the lizard they are found beside the terminal plates, chiefly in the young muscular fibres.

The most simple form of these terminations is shown in the tortoise; nerve-fibres, destitute of myeline, ramify without anastomosing, and terminate on the muscular fasciculi, by branches which sometimes are smooth, but which most often are moniliform, or surrounded by grains deeply coloured by the gold. These grains,

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* See p. 250.

which are placed around the terminal branches, are sometimes so numerous, that their *ensemble* presents an appearance similar to that of the terminal arborization of a little motor plate.

These new forms of nerve terminations all present this peculiarity, of only being found on nerves destitute of myeline, although these always arise from nerves with myeline. In the snake, these fibres without myeline may even have a very long course.

In the case in which the nerve terminates in the muscle by a well-developed plate, never more than a single plate is observed for one whole muscular fibre; when, on the contrary, we deal with the terminations which we have just described, we generally meet with several nerve terminations on the same muscular fibre. And in the snake their number may even be from six to seven.

A more detailed work, accompanied with plates, will shortly be published.*

Observations on Saprolegnieæ.—Mr. Frank B. Hine, B.S., has recently studied this group, specimens of *Menobranchus lanceolatus* kept in a tank having been attacked by a form which he places under the genus *Saprolegnia*. After defining the Saprolegnieæ as "aquatic, parasitic, nearly colourless plants, appearing to the unaided eye merely as a light greyish or white cushion-like mass of fine filaments," and describing the appearance of the fungi and their mode of development (with 4 plates), he gives some details as to the rapidity of their development.

"In studying, and especially in growing these forms, one can but notice the rapidity with which they develop, especially under favourable conditions. Illustrating this point, I introduce the following table, which embraces the results of timing the growth of a young and thrifty filament under a magnifying power of 200 diameters. For the first hour, observations were taken every five minutes; during the second, every ten minutes; after which the time varied. The first column represents the time of measurement, and the second the length of filament.

Table showing Rapidity of Growth.

h. m.	Length.
9 7	5 mm.
9 12	11·1 „
9 17	16 „
9 22	22·3 „
9 27	28·9 „
9 32	35·2 „
9 37	41 „
9 42	47·5 „
9 47	54·7 „
9 52	62·3 „
9 57	70·1 „
10 2	78·1 „
10 12	91·2 mm.
10 22	110·3 „
10 32	125·1 „
10 42	137·3 „
10 52	149 „
11 2	169·8 „
11 22	208·4 „
11 32	221·7 „
11 42	231·1 „
11 52	241 „
12 2	241 „

From these data it will be seen that growth for the first hour averaged 6·5 mm., for the second 7·64 mm., and for the third about

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* M. Tschiriew, in 'Comptes Rendus,' vol. lxxxvii. p. 604.

6 mm.; this, it will be remembered, under a magnifying power of 200 diameters. Growth during the remainder of the day averages considerably less; but judging from the appearance of the plant at eight o'clock the next morning, I think the growth had taken place as rapidly as when the first measurements were taken. The branches shown were given off at 10.7 and 10.42 o'clock, and averaged 7·8 mm. per five minutes. The time required for a plant to develop fruit from the zoospore, varies greatly with varying conditions. A mat of mycelium, from which the specimen was taken, developed fruit in four days, but this time was rather long when compared with other observations made on the same germs, considering that the mycelium was already well developed. In one case, zoospores were placed upon a slide with a small fragment of a fly; the first sporangium opened in about thirty hours, and the second one on the same filament eight hours later." *

Life-History of Bacterium termo and Micrococcus.—Dr. J. Cossar Ewart has communicated a paper to the Royal Society, from which the following is extracted:—" While recently studying the phases through which *Bacillus anthracis* passes, my attention was often directed to still more familiar organisms, *Bacterium termo and Micrococcus.* Frequently from cultivations of *Bacillus*, both rods, spores, and filaments disappeared, and in their place millions of *Micrococci* and the short jointed rods of *B. termo* were found.† In the short rods of *B. termo*, which in the struggle for existence overcame the less active *Bacilli*, minute bright particles were often present. These exactly resembled the *Micrococci* in the field around and between them, and were evidently the remains of spores out of which the rods had just been developed. The presence of *Micrococcus*-like spores in the short rods led me to conclude not only that *B. termo* had a life-history similar to that of *Bacillus anthracis*, but also that Billroth was probably right in believing that *Micrococci* were the spores of ordinary *Bacteria*. . . . Before attempting to compare the life-history of *B. termo* with what we know of the life-history of *Bacillus anthracis*, it was necessary to have *B. termo* isolated from all other organisms. After many failures, I was fortunate enough to find a cultivation in which the rods of *B. termo* were alone visible. After keeping this cultivation under observation for some time, others were made by infecting fresh drops of *humor aqueus* previously placed on absolutely clean covering glasses with as small a drop of the liquid as possible on the point of a needle. The covering glasses were inverted over cells made by fixing glass rings to ordinary slides by means of Brunswick black, the cells having been carefully washed immediately before using with absolute alcohol. A thin layer of olive oil between the edge of the glass ring and the covering glass prevented evaporation, and the entrance of moisture and solid particles from the surrounding atmosphere.

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* 'American Quarterly Microscopical Journal,' vol. i. p. 18.

† This disappearance of the one and appearance of the others accounts for early investigators believing that there was a continuity of development between *Bacilli* and septic organisms.

In cultivations of *B. termo* prepared in this way, and kept at a temperature of 30° C., I made out that, under certain conditions, the rods, instead of undergoing fissiparous division, lengthened into filaments, in which in due time spores appeared, which, having been free for some time, subsequently germinated into short slender rods. . . .

I next directed my attention to *Micrococcus*, in order, if possible, to make out whether it was a distinct organism, or whether it was simply a phase of the life-history of some common *Bacterium*, e. g. *B. termo.* After making numerous preparations, I at last succeeded in getting a cultivation in which only *Micrococci* were present. The cultivation was made by adding to a drop of *humor aqueus* from a fresh ox's eye a minimal quantity of pus from a newly opened abscess on the point of a calcined needle. For three days there was no indication of organisms, but on the fourth, small moving particles were visible, which, when examined with a No. 12 immersion (Hartnack), were seen to be either round, oval, or dumbbell-shaped, and often in groups of two and four.

A long and careful study proved that the different forms were all phases of the same organism; the oval forms became dumbbell-shaped, and then divided into two round bodies, similar to, but smaller than the sporules of *Bacillus anthracis.* The two round bodies moved actively about till they separated from each other, when each became dumbbell-shaped and divided as before. . . .

Though kept under observation for three weeks, not one of the round or oval organisms present ever germinated into a rod. . . . Hence, having failed to find *Micrococcus* developing into bacterial rods, it may, in the meantime, be inferred that it is a distinct form; or just as *Torula* may be an arrested phase of some *Penicillium*-like organism, so may *Micrococcus* be the spore of a *Bacterium* which has either altogether lost its power to germinate, or can only do so under very peculiar conditions. That *Micrococcus* closely resembles *Torula* will be at once apparent.

If the oil be removed by blotting paper from between the glass ring and the covering glass of a preparation made as above described, or if the covering glass be fractured without being displaced, the cultivation liquid rapidly evaporates, and the remains of what a few minutes before were active organisms are in great part left adhering to the under surface of the covering glass. Preparations treated in this way may be either subjected to high or low temperatures, or, when protected by a glass cap, may be left in the ordinary atmosphere. The result of desiccation was ascertained by infecting flasks containing sterilized organic infusions. Such flasks infected with rods desiccated at 20° C. remain sterile, but flasks infected with desiccated spores soon teem with *Bacteria*, and flasks infected with desiccated *Micrococci* soon teem with round, oval, and dumbbell-shaped organisms, leading to the conclusion that desiccation destroys bacterial rods, but that, though continued for weeks, it has no influence on spores or *Micrococci.* If *Micrococci* and the spores of *B. termo* are not destroyed by desiccation in a small protected atmosphere, it may be further inferred that they retain their viability when dried in the ordinary atmosphere, and being extremely small and light, that after they are dry they will float about along with other solid particles in disturbed, and settle down in quiet atmospheres without undergoing any change until they find themselves in a medium which admits of their growth and development. In all probability, desiccation destroys the oval and dumbbell-shaped forms of *Micrococcus*, the round spore-like forms only retaining their vitality. . . .

Along with Dr. Burdon Sanderson,* I have shown that the spores of *B. anthracis* are destroyed when the fluid they are suspended in is kept for a few minutes at the point of ebullition. The same is true of *B. termo* and *Micrococcus.* On the other hand, when they are subjected to a temperature of 110° C. in a dry state, they are not destroyed; they are rendered inactive, however, by a temperature of 120° C. The difference between the effects of moist and dry heat is probably owing to the gelatinous capsules of the spores and *Micrococci* giving way, and thus allowing the boiling fluid to come into direct contact with the unprotected central protoplasm."†

Life-History of Spirillum.—Dr. Ewart in conjunction with Mr. Patrick Geddes also contributes a paper on *Spirillum.* They point out that, notwithstanding the numerous and fruitful researches which have been recently made into the life-history of *Bacteria*, our knowledge of the common and interesting curved and spiral forms—the *Vibrio* and *Spirillum* of Ehrenberg—has made little or no advance since his time, neither embryonic nor reproductive forms having ever been observed; while even the zooglœa phase, so characteristic of *Bacterium* and *Bacillus*, has only been once mentioned,‡ and then in a different form. (The authors add in a note that they are very strongly of the opinion that the forms described by various authors as *Vibrio* are merely either (1) zigzag dividing *Bacillus*, (2) slightly waved *Bacillus*, or (3) undeveloped *Spirillum*, and hence that *Vibrio* should no longer be used as a generic term.)

The life-history of *Spirillum*, so far as at present known, is thus summarized. The well-known motile corkscrew may alternate between the active and resting states, and ultimately lengthen out into a small filament, which loses its definite twist and may freely bend or straighten. This thread grows into a much larger and longer motionless filament, in which spores appear. These rapidly divide and acquire a bright brown colour, the filament reassuming the motile condition, and sooner or later breaking up. The freed spores encyst and divide, forming capsules, which after a period of quiescence themselves become motile, the sporules contained in them escape and germinate into "commas," which become *Vibrio*-like, and soon grow into the common motile *Spirillum.*

The resemblance of all this to the life-history of *Bacterium termo* and *Bacillus* described in the preceding paper is at once apparent. Not only is there the same alternation of a resting with a motile phase, but there is a lengthening into filaments, the protoplasm of

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* 'Quart. Jour. Micro. Science,' April, 1878.

† 'Proc. Roy. Soc.,' vol. xxvii. p. 474.

‡ Lankester, 'Quart. Jour. Micro. Sci.,' vol. xiii. p. 424.

which condenses into spores which divide and germinate. Moreover, there are also moving filaments, and finely granular spheres, while the resemblance to *B. rubescens* is even more striking. That the deeply coloured spherules, figured by Lankester in the filaments and capsules, and described as "loculi," as well as the so-called "sulphur-granules" of Cohn,* correspond to the "spores" of the authors is extremely probable, although their germination has not yet been observed.†

On this paper Professor Ray Lankester writes:‡—"I have no doubt from their description and from observation of the same growth that the organism present was identical with my *Bacterium rubescens.* During the phase in which they observed it the production of *Spirillum*-forms was exceedingly active. The *Spirillum*-form observed by Ewart and Geddes and the filaments related to it appear to be identical with those described and figured by Warming.§ Professor Giard, of Lille, has also figured the same *Spirillum*-form of *Bacterium rubescens* in the 'Revue des Sciences Naturelles,' tom. v., 1877. I do not feel satisfied from the account given by Ewart and Geddes that the bodies which I have called 'loculi' and which they term 'spores' have any characters which justify the use of the latter term in regard to them. They do *not* appear to be the same kind of bodies in origin as the so-called 'spores' discovered by Cohn in Bacillus, and it is not at all certain that they germinate, as Ewart and Geddes have inferred, though their observations lend a certain amount of probability to that suggestion."

Observation of Live Aquatic Animals.—The microscopical study of live aquatic animals is often very tedious and unsatisfactory on account of their almost constant motion. This may be very effectually overcome by adding a small quantity of sulphuric ether to the water in which they are kept. Ether is a very excellent quieting agent, as it mixes quite readily with water, it does not sensibly affect the circulation, and the animals are as lively as ever soon after being put back into fresh water. ||

Unit of Micrometry.—The resolutions of the Indianapolis Microscopical Congress, which are printed at p. 254, were considered at a recent meeting of the New York Microscopical Society, who resolved to approve of the first one, viz. the recommendation of the $\frac{1}{100}$ of a millimetre as the unit. After some discussion the other resolutions were "laid on the table."

The proposed Micro-Metric Unit.—These resolutions evidently do not find favour with the editor of the 'American Journal of Microscopy,' who somewhat severely criticizes them in an article under the above heading in the October number, and from which we make the following extracts:—

That the metric system will ultimately be the one universally

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* 'Beiträge zur Biol. d. Pfl.,' 3, 1875.

† 'Proc. Roy. Soc.,' vol. xxvii. p. 481.

‡ 'Quar. Jour. Mic. Sc.,' October, 1878.

§ 'Observations sur quelques Bacteries qui se rencontrent sur les côtes du Danemark.' Société d'Hist. Nat. de Copenhague, 1875.

|| Mr. Gage, in 'American Quarterly Microscopical Journal,' vol. i. p. 71.

used, there can be no doubt, and those who are about to provide themselves with an entirely new set of standards would do well to adopt for general work the metre or one of its subdivisions, but our power to reduce inches to millimetres by calculation (1 mm. = 0·03937043 inch) greatly exceeds in delicacy our power to make observations, and where any observer has already employed the inch or is provided with standards which he has carefully examined and compared, it becomes a serious question whether or not he should make a change.

It may be well, however, to bear in mind that it is not more than once in a hundred times that micrometric measurements are stated in *absolute* quantities, that is, in terms of the inch or metre. In most cases the micrometer is used merely to ascertain the extent to which the object is magnified, and this is generally effected by placing a micrometer on the stage, and making a drawing of its divisions under the same power that the object itself is drawn. The drawing of the enlarged image of the micrometer then becomes a scale for measurement, its absolute value being determined by applying to it an ordinary rule or measure. For this purpose the particular standard that is used is of no consequence whatever, but so long as foot rules and scales divided into inches are more common than rules divided into millimetres, just so long will micrometers expressing divisions of the inch be more generally convenient than micrometers divided after the metric system. The measurements of blood-corpuscles are perhaps the only absolute measurements generally made, and in the literature of this subject (at least, that in the English language, which, by the way, is the best literature relating to it) the divisions of the inch are always used. Those who propose to investigate this subject, will save themselves much useless labour by employing a micrometer having divisions of the inch.

The proposition to use the so-called metric standard in preference to the inch and its subdivisions may therefore be dismissed as one having little power for good or ill. As the metric system comes into use generally, so it will come into use amongst microscopists, and not till then. Every scientific man will, of course, hail its adoption with pleasure.

The proposal to use the $\frac{1}{100}$ of a millimetre as the new unit is, however, of a much more mischievous tendency. It puzzles us to see to what possible advantage it can give rise, or why it should have been brought forward at this day, after having been proposed by Harting years ago, and justly consigned to oblivion by all intelligent workers. The principal reasons for and against the adoption of a $\frac{1}{100}$ of a millimetre as a so-called unit are as follows:—

In favour of it we have the avoidance of fractions, of which the following may be taken as an illustration:—The $\frac{1}{100}$ of a millimetre is about the $\frac{1}{2500}$ of an inch; instead therefore of speaking of the $\frac{1}{833}$ of an inch we might use the term "three units," which at first seems more simple and easy of expression. In fact, however, it is not so. A "quarter of a yard" is an expression quite as easily comprehended as "nine inches." And, unfortunately, if this be the object, the unit is far too large. Harting saw this difficulty a quarter of a century ago, and sought to avoid it by making his unit the $\frac{1}{1000}$ of a millimetre, which is the one-tenth of Professor Hitchcock's proposed unit. This unit Harting proposed to call the *micro-millimetre*, and to designate it the letters *mmm.* were employed. Thus we had *m.* for the metre, *mm.* for the millimetre, and *mmm.* for the micro-millimetre. But even Harting's unit was too large, and why Professor Hitchcock should have gone back half a century and suggested a centi-millimetre, passes our comprehension.

Such a proposition is, however, open to the fatal objection that it introduces a new term which must be unintelligible to all except microscopists. For example, an engineer finds a paper in which he is interested, and in which the quantities are given in the new unit; how is he to avoid the most serious mistakes unless each paper, no matter what its subject may be, shall first give a full explanation of the measures used? The truth is, that this proposition tends to separate microscopists from all other scientific men by establishing new and unnecessary units, notations, and terms. And the absurdity of such a suggestion is at once obvious, when we reflect that all this fuss is made merely about the placing of a decimal point, for that is really all that it amounts to. The metre and millimetre are well-known and universally recognized units, having familiar contracted designations *m.* and *mm.* To urge the adoption of a new unit is as much a backward step as it would be to attempt to revive the old wine and beer measures, and bring them into use for special liquids.*

Wartelia, a new Genus of Annelida, wrongly considered as the Embryo of Terebella.—In 1845, in his memoir 'On the Development of the Annelida,' Milne-Edwards, after having described and figured the transformations of *Terebella nebulosa* of Montagu, added: "I am inclined to believe that, from not having known these metamorphoses, the larvæ of *Terebella* have been taken for special types, and thus genera have been uselessly multiplied." Since then, the larvæ of the Annelida have been much studied, and an opposite error has arisen. This has happened because instead of following step by step the embryo of any given species, from the egg, isolated after its extrusion, as was done by Milne-Edwards, some naturalists have employed in their researches larvæ caught in a fine net, a method which requires the greatest care in its application to embryogeny. It is thus that Claparède,† in his 'Observations on the Anatomy and Development of the Invertebrata,'‡ describes and figures, as different stages in the evolution of *Terebella conchilega*, young Annelids, which have in reality no genetic relationship with this type, so common on the coasts of the English Channel and of the North Sea.

The observations of Claparède were made at Saint-Vaast-la-

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* 'American Journal of Microscopy,' vol. iii. p. 236.

† 'Beobachtungen über Anatomie und Entwickelungsgeschichte wirbelloser Thiere an der Küste von Normandie angestellt.' Leipzig, Engelmann. 1863.

‡ Pp. 63–69; pl. viii. figs. 12 and 13; and pl. ix.

Hougue; I have recently at Wimereux met with the same species of Annelid, which lives in the adult state under very peculiar conditions: it is in reality one of the most interesting forms for the genealogical classification of the Chætopoda. If we examine attentively a corm of *Laomedea gelatinosa*, we frequently find on the branches of this Hydrozoon, small transparent upright tubes, which may easily escape notice, so exactly do they imitate the gonothecæ of the Campanularia. Each of these tubes is inhabited by a pretty transparent Annelid, which only differs from the assumed embryo of *Terebella conchilega** in having the seven tentacles practically equal to each other; at least the median one exceeds the six lateral ones but very little in length. The presence of generative products in a good many individuals assures us that these Annelids are adult. The existence of voluminous otocysts, exactly similar to those of the Molluscs, the peculiar form and disposition of the *tori uncinigeri* at the extremity of the ventral cirrhi of the posterior part of the body, enable us to class this Annelid in a new genus, much farther removed from *Terebella* than has been hitherto supposed, and presenting affinities with several families of Polychetes. I dedicate this genus to my pupil Adolphus Wartel, who was the first to find the Annelid. I call the species *Wartelia gonotheca* to recall the curious mimetic character which I have noticed above. The disposition of the tube of *Wartelia* gives it also a certain resemblance to the tubicolous Rotifers.

After the preceding facts, a retrogressive metamorphosis and a transformation so complete as Claparède had thought it, is out of the question for *Terebella* The embryogeny of *Terebella conchilega* ought to be entirely re-examined; the most complete observations which we possess at the present day on the development of Annelida of the genus Terebella are those of Milne-Edwards relating to *Terebella nebulosa*, Montagu.

Near to the *Wartelia* should probably be classed a tubicolous Annelid from the Mediterranean, described by Wilhelm Busch,† as well as the genus *Lumara* of Stimpson.‡ Perhaps even the larva figured by A. Agassiz § as the embryo of *Terebella fulgida*, Agassiz, may also be only an embryo of a form nearly approaching *Wartelia*; this is what may be supposed from the general aspect of the animal and the presence of highly developed auditory capsules. It is known, indeed, that this auditory apparatus only exists in a very small number of Annelids, in other respects far removed from those which form the subject of this note.‖

Hyalodiscus subtilis (Bailey).—Mr. F. Kitton, Hon. F.R.M.S., sends

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* Pl. ix. fig. 6, of Claparède.

† 'Beobachtungen über Anatomie und Entwickelung einiger wirbellosen Seethiere.' Von Dr. W. Busch. Berlin, 1851.

‡ Stimpson (W.), 'Marine Invertebrates of Grand Manan,' 1853, p. 30. I have not been able to procure this work, which I quote from an extract of A. Agassiz.

§ "On the Young Stages of a few Annelids" ('Annals Lyceum Nat. Hist. of New York,' vol. viii., June, 1866), pp. 320, 321, pl. vii., figs. 19 and 19*a*.

‖ M. Alf. Giard, in 'Comptes Rendus,' vol. lxxxvi. p. 114.

the following note:—In my remarks on this form in the previous number (p. 239), I find I am mistaken in supposing that there were no objectives of sufficient defining power to resolve the Californian Hyalodiscus (*H. Franklinii*) when Professor Bailey published his species. In his 'Notes on some new Test Objects' he mentions objectives made by Spencer, and Powell and Lealand, capable of resolving tests as difficult as the markings on *H. Franklinii.*

Schmidt's Atlas der Diatomaceen-Kunde.—Mr. Kitton also kindly contributes the following:—The long delay in the publication of parts 15 and 16 has arisen from the continued illness of the author. We are glad to say that he is now recovering, and he hopes to be able to publish the future parts with greater regularity.

The parts just received are devoted to that very puzzling genus, Coscinodiscus, of which 218 figures are given. The majority of them are excellent delineations, and can be easily recognized.

We think that too many figures of one species are given, the differences being much too slight even to constitute varieties; for example, *C. subtilis*, which differs but little from *C. fasciculatus* (by the way, the Rev. E. O'Meara describes and figures a species under this name in the 'Q. M. J.,' vol. vii., N. S., p. 249, pl. vii. f. 1, but it is not the same as Schmidt's species. He afterwards, in his 'Irish Diatoms,' refers it to *C. Normanii* of Greville, which does resemble Schmidt's *C. fasciculatus*, but which certainly does not resemble O'Meara's). *C. curvatulus* is probably only a variety of *C. subtilis.* Greville's *C. symmetricus* is simply distinguished by its larger granules. *C. extravagans* must be referred to Aulacodiscus if the generic characters of that genus are of any distinctive value. Judging from the figure, we should be disposed to think it an immature valve of *A. Oregonus.* Fig. 34 (unnamed) is no doubt also a member of that genus, as the author surmises. *C. cocconeiformis* is a very doubtful Coscinodiscus; it approaches very near to *Cocconeis superba*, Janisch, the principal difference being its circular outline, a distinction of little value. *C. denarius* closely resembles *C. Barbadensis* of Greville.*

Part 16 contains many admirable figures of the large-celled Coscinodisci; many, however, appear to us to have no claim to be considered distinct species or even varieties. *C. bulliens* is the form usually considered by English diatomists to be the true *C. heteroporus* of Ehrenberg.

In this part we have 67 figures, of which only 18 are named. *C. robustus*, Greville, is probably the same as *C. marginatus*, Ehr.

We have in previous notices of this work expressed our regret that so many figures are given to illustrate differences which are of no specific value. As our knowledge of these forms increases, we see that characters that were once considered to be good specific or generic distinctions, are now valueless. We have Triceratia that are circular, Coscinodisci with three and four sides, and Pleurosigmas perfectly straight.

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* 'Trans. Mic. Soc.,' vol. ix. p. 45.

The Atlas up to the present date contains 2230 figures illustrating the following genera :—

	Figures in Atlas.	Species in Habirshaw's Catalogue.
1. Actinoptychus	41	62
2. Amphora	369	196
3. Asteromphalus	24	34
4. Aulacodiscus	64	55
5. Auliscus	75	46
6. Campylodiscus	196	115
7. Cocconema	35	35
8. Coscinodiscus	218	129
9. Cymbella	79	119
10. Encyonema	34	19
11. Navicula	876	830
12. Surirella	219	221
	2230	1861

In the above table we have compared the number of figures in each genus with the number of species in Habirshaw's Catalogue. It will be seen that in most cases the figures are much in excess; but on comparing the names in the descriptions of the plates, we find the actual number of species figured is much below that in the Catalogue; for example, in the genus Actinoptychus we have 41 figures representing 23 species; Aulacodiscus, 64 figures, 24 species. A large proportion of the generic (330) and specific (6186) names in the Catalogue are only synonyms; but estimating the actual number of genera at 150, if the work is continued on its present scale, it will require 200 parts to complete it, and its publication will extend to fifty years.

Application of Freezing Methods to the Microscopic Examination of the Brain.—Mr. Bevan Lewis, F.R.M.S., contributes the following (with additional matter) to 'Brain':*—"Our handbooks teem with descriptions of the most approved methods of preparation by hardening reagents, but I cannot recall to mind any description of the method to be adopted for examining the brain in sections obtained by freezing, and I therefore purpose describing the method adopted by myself, feeling convinced that it will be fully appreciated by those who have up to the present employed the tedious process of chrome hardening, and suffered, as I have personally, from the numerous disappointments attendant upon the exclusive use of this method. It appears to have been the opinion of several microscopists who have employed the chrome salts exclusively, that the freezing method was wholly inapplicable to the investigation of the central nervous system, and several authorities in cerebral histology had expressed to me such an opinion. Results obtained by at least one German observer and my own work at the West Riding Asylum prove this view to be incorrect.

I was led to the employment of ether for freezing tissues, after having experienced numerous difficulties in the use of the ice and

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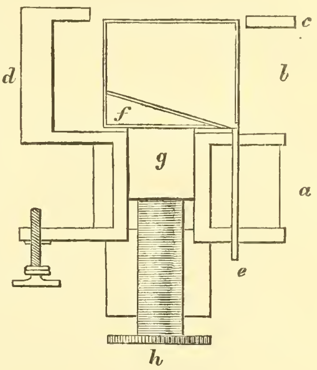
* 'Brain,' vol. i.

salt mixture. The process was so tedious that a more expeditious method appeared desirable, and I therefore constructed an instrument for freezing with ether spray, and described it in the 'Journal of Anatomy and Physiology' for April, 1877. At this time I was informed that an instrument was described by Mr. Hughes in the same journal twelve months previously; but finding my microtome simpler in construction and more expeditious in freezing, I have employed it, with some slight modifications, up to the present time. The woodcut represents in vertical section the freezing microtome which I constantly employ, and which I can very strongly recommend for general use. The lower half (*a*) is in principle an ordinary Stirling microtome; the upper half consists of a freezing chamber (*b*) and the section plate (*c*). As regards the microtome, I always insist upon the use of an oval instead of a circular plug (*g*), whilst the screw should be three-quarters of an inch in diameter, finely worked, and with a milled head at least $1\frac{1}{8}$ of an inch wide. The freezing chamber (*b*) should have a false sloping bottom (*f*) leading to an exit tube (*e*), which conducts off the condensed ether. Extremely simple as this contrivance appears, it is absolutely necessary for success that attention be paid to the following details of construction. The freezing chamber consists of a large hollow cylinder of zinc, slightly over two inches in diameter, and capped with a plate of the same metal. This cylindrical chamber is soldered on to the microtome plug, so as to ensure absolute steadiness in working, and it possesses three circular openings three-quarters of an inch in diameter, one placed in front of the two others laterally opposite each other. The section plate (*c*) is also made of zinc $\frac{3}{20}$ of an inch thick, and raised upon the vertical arm (*d*), also made of the same metal. The opening in the section plate should be sufficiently large to allow of the free play of the freezing chamber (*b*) through it without affording any point of contact between the two. With a freezing chamber such as the one described, beautifully large and thin sections may be obtained with ease. The material employed in the construction of the freezing chamber and section plate is a matter of importance, and I met with frequent failures and disappointments when endeavouring to utilize other more workable metals; brass above all metals was found unsuitable, and zinc alone fulfilled all the requisite conditions. Theoretically, it was supposed that the metal chamber should be covered with a non-conducting material, such as felt, wood, &c., and that the conduction between the section plate and body of the microtome should in like manner be cut off; but practically it was found that at the sacrifice of a small amount of ether rapid



freezing could be ensured and a large number of sections obtained before the tissues became loosened from the freezing chamber. It should be remembered, that to avoid the expense and incumbrance of a special condensing apparatus we have to provide for the free evaporation and subsequent condensation of ether in the same chamber, and consequently a sacrifice of about one-fourth the bulk of ether used is sustained. I regard as the requisite of a good freezing microtome the following conditions:—

1. The instrument should be of the greatest possible simplicity.
2. The freezing should be rapid and expeditious.
3. The metallic constituents should be such as to retard thawing of the tissue when once frozen.
4. A minimum of ether should be expended.

Now, I would claim for my instrument a fulfilment of these conditions as far as is possible, without the employment of an exhausting and condensing apparatus; and I would on these grounds advocate its use by those who require a most satisfactory microtome, and one comparatively inexpensive. The first condition, that of simplicity, is too self-evident to dwell upon; the second also is ensured, as the tissue is frozen in less than twenty seconds, whilst it remains adherent to the cover of the freezing chamber for a period sufficing for the cutting of a dozen sections or more. A very small quantity of ether suffices for freezing, and three-fourths of its bulk becomes condensed, and may be collected in a bottle attached to the tube (*e*). I used a graduated bottle for the ether spray, and can thus read off the amount of ether expended in freezing. The costliness of ether has been urged against its employment in ordinary section cutting by one authority of note, and the objection would prove of great weight in case a large amount of ether was lost at each operation; it is but necessary, however, that the instrument be once seen in good working order to dispel all such notions from the mind, as the results obtained are of the first order, and the expenditure of ether very trivial."

The paper includes a description of the method of cutting sections of brain, but space prevents any further extract here, and the original may be profitably referred to.

Angular Aperture defined.—Professor Romyn Hitchcock, of New York, brought this subject before the Indianapolis Congress. In order that the term "angular aperture" should mean something definite, and to avoid ambiguity and misunderstanding in future discussion on the subject, he proposed to adopt a definition of the term which, right or wrong, should be recommended to the microscopists of the country as a convenient and uniform usage. The triangle method was proposed for general adoption, considering the angular aperture of a microscope objective to be the angle of the apex of a triangle having a base equal to the available diameter of the front lens, and a height equal to the actual focal length (working distance) measured in air for a dry lens, and in the fluid employed for an immersion lens, the collar being adjusted for the most perfect definition in every case.

While nearly all the members seemed to be personally in favour of the usage proposed, a motion that the Congress should attempt to settle the question by requesting its general adoption met with so much opposition that it was withdrawn.

Trichodonopsis paradoxa (*Clap.*).—The position, as regards classification, of this genus of Ciliate Infusoria, is said by the 'Micrographic Dictionary' to be doubtful. It resembles externally one of the Vorticellina, but is covered with well-developed cilia. The species *T. paradoxa* inhabits in myriads the intestines of *Cyclostoma elegans.*

M. A. Schneider contributes a note in regard to it to 'Comptes Rendus.' He says "it is common amongst the Cyclostomata of the neighbourhood of Poitiers. Its study has developed some interesting facts (complementary to those of Claparède and Stein), which I will briefly describe.

The cuticle presents over the whole of its surface, a very finely punctated appearance, resulting from the presence beneath it of an uninterrupted layer of little rods of circular section, disposed in 'palisades,' as may be seen in profile views. They are most easily observed on the basilar membrane of the disk. They resemble, in form and position, trichocysts, although without urticating filaments, and although they exist, as I have said, on the basilar membrane, which is constantly naked, without cilia or other appendages.

The problematical organ in the form of a solid cap, regarded by Claparède as muscular, and left undetermined by Stein, is the nucleus. It is hollowed out on one side; and in the notch, or opposite to it, is a small, very distinct spherical nucleolus.

This shows—1st, that the problematical organ and its satellite (nucleolus) are the only parts of the body which give with acids and colouring substances the characteristic reactions of the nuclear matter; 2nd, that several Trichodinæ, especially *Neritilia fluviatilis*, have a nucleus and a nucleolus, which correspond topographically to the organs which we consider as identical in the *Trichodonopsis*; 3rd, that the problematical organ, occasionally single, is sometimes double, triple, or quadruple; its division may indeed go farther, and it is not uncommon to find in the body six or seven tolerably large spherules, and from thirty to eighty smaller granules, representing altogether the nucleus of which they give the reactions; the nucleolus appears to remain undivided whilst the nucleus undergoes this fragmentation: it is thus shown that the problematical organ plays the same part here as the nucleus of the infusoria in reproduction by rejuvenescence; 4th, the impossibility of calling that a nucleus which Claparède and Stein have wished to consider as such in *Trichodonopsis.*

This organ, indeed, which surrounds the digestive apparatus, does not fix colouring reagents; its structure is special; its thickness is most commonly occupied by more or less bulky *calculi;* in fact, its very existence is not constant, for it is wanting in a whole category of individuals which are distinguished at the same time, by slight differences in the conformation of the superior extremity, and chiefly by an entirely different arrangement of the digestive apparatus; and this in such a degree that there is a real dimorphism in relation to the existence or absence of this organ, which can only be in my eyes a part fulfilling a very secondary glandular rôle.

The use of reagents has also enabled me to rectify several points relative to the structure of the disk and to the conformation of the digestive apparatus, of which I hope soon to publish the exact figures." *

Importance of the Vegetable Cell-walls in the Phenomena of Nutrition.—M. Max Cornu writes (in 'Comptes Rendus'):—"Sections of vegetable tissues sometimes extract the colour from solutions; certain regions are brightly coloured, whilst others remain uncoloured. On immersing a transverse section of a monocotyledonous stem in a weak solution of fuchsine, the sheaths of the fasciculi and the thickened walls colour brightly; in ammoniacal carmine, to all appearance of the same colour, the elements which are coloured are very different, being those which the sheath surrounds.

Colouring matters, with sufficient power, are thus divided into two groups; one being taken up by the thickened elements, the other not.

The thickened elements are the woody fibres and cells of dicotyledonous plants, hypodermic fibres, certain vessels, certain fibres of the liber, the sheath of monocotyledonous fasciculi, and generally the most external part of the cuticle; but these elements must be full grown.

The elements of the other group are young or thin, and generally covered with only a thin layer of protoplasm: these are the cells of the cambium, scalariform vessels, the collenchyma, &c. The ordinary cells, the vessels, and other elements may, according to the plants or the part of the tissue, be classed in one or the other category. The distinction of these two groups is easily obtained by means of sections of herbaceous stems of dicotyledons or of monocotyledons; it is well to destroy the contents of the elements by acetic acid and to employ weak solutions.

The fixing of the colouring matters depends on the relative density of the wall; we get only an imperfect idea of this density from the colour and refraction. It is possible to follow by means of these reagents, the accumulation of new substance in the wall; the resorption of this wall in the spiral vessels of the fasciculi in process of elongation (Umbelliferæ, Cucurbitaceæ, &c.) is also easily observed.

The ordinary chemical reagents easily show that the colouring has no relation to the chemical composition; I have been able to study with this end, the pure products of M. Fremy (cutose, vasculose, cellulose), separated from the mass of complex substances.

From a physical point of view these data were wanting.

We know the importance of the cell-wall in the interchange between the cells and the ascent of liquids; the experiments of M. Jamin have shown the value of certain physical forces, and notably of imbibition. But more than that, the walls may be the reservoirs in which are accumulated certain soluble principles drawn up by the

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* 'Comptes Rendus,' vol. lxxxvii. p. 537.

root; it is thus easy to understand that the sap may be almost pure water, and that it could scarcely concentrate itself in the upper parts of the plant, subjected during summer to a considerable evaporation. The theory of the descending sap and the other theories left, in this respect, grave difficulties unsolved.

As to the substances which do not fix themselves on the walls of the elements, we imagine therefore that they must circulate in the plant in a very different manner. There is then a distinction to establish from a physical point of view, with reference to the cell-wall, in the absorption and the migration of the substances dissolved.

One of the groups of colouring substances contains (in the order of the colours of the spectrum):—

Aniline black, hematoxyline, Coupier's blue, osmic acid, cyanide of iron, aniline blue, rosollic acid, ammoniacal carmine, juice of phytolacca, &c.

The other contains:—

Methyl-violets and quinoline violet, diphenylamine blue, aniline green, Coupier's green, aniline yellow and brown, permanganate of potash, coralline, sulphocyanide of iron, fuchsine, rosonaphthaline, &c.

These properties may be utilized, in approximate analyses, to eliminate easily certain substances sought for (in wines, syrups, &c.), or to concentrate them.

The sulphocyanide of iron acts upon the thickened elements (like the perchloride) and colours them the colour of dragon's blood; nevertheless a similar section rapidly loses colour in the cyanoferride of potassium, and precipitated cyanide of iron acts upon thin and plasmatic elements. It is seen that the secondary reactions may much modify the primitive distribution of the substances. In experiments on nutrition, reactions of this kind may give rise to errors.

The protoplasm and the nuclei of the elements when dead are rapidly coloured by the substances which act on the thick parts; but the whole easily loses colour. The substances of the other group colour more slowly, but in a more permanent manner, the nucleus especially. Experiments made in collaboration with M. Mer have enabled us to understand this fact.

The explanation of these phenomena of fixation are based on a physical action very similar to capillarity; the dimensions of the molecules and their interval ought probably to be considered: but this is not the place to dwell upon it.

To sum up, we see that physical forces may separate the matters absorbed by the plants from one another, according to a law easily demonstrated experimentally with coloured substances: very important consequences in regard to the phenomena of nutrition may be deduced therefrom." *

Mechanism for the Fertilization of Meyenia erecta.—Mr. R. Irwin Lynch, of Kew, describes, in the 'Journal of the Linnean Society,' a previously unobserved mechanism in this plant (an acanthaceous shrub of tropical Africa) for cross-fertilization. The anthers, which are

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* 'Comptes Rendus,' vol. lxxxvii. p. 303.

provided with hairs, are placed midway in the tube of the funnel-shaped, slightly curved, horizontal-lying corolla, their backs pressed against its upper wall. The style is as long as the tube, and runs along a little groove in the roof. The stigma consists of two lips; the upper is folded into a tube, and points straight forward. Through this lip alone is it possible for the pollen to fertilize the ovules. Pollen touching the lower lip would seem to be of no avail. What, then, is its use? In contrast to the other lip, it is spread open, and projects downwards over the entrance to the tube. Its use is to act as a lever in this way: if an insect alights on the limb and essays to enter, in so doing the lever is pushed in, so that the receptive surface of the upper lip is brought down on its back, where lies a supply of pollen from another flower. In this way, pollenization is secured. Passing on, the insect releases the lever, and the stigma assumes its former position. Now we have to see how, in the first place, the back of the insect became charged with pollen. In going to and returning from the nectar at the bottom of the flower, it would evidently brush the pollen off the hairs of the anthers above, by which it has been retained. This, then, is the use of the anther-hairs; had the pollen fallen to the floor of the tube, it could not have been carried away. The insect now has to pass out, and again the lever lip of the stigma comes into action. Just as it effected pollenization when the insect entered, so now it prevents contact of the pollen of its own flower. The upper and receptive lip is pushed up out of the way by pressure from within against the lever.

Under the microscope, I find that the edges of the two lips appear to be different; the papillæ of the receptive lip are shorter than those of the lever lip, and its edge is thickened. I am indebted, however, to bright weather for a strong confirmation of the mechanical views I have above expressed. I have then observed that the receptive lip has been bathed with mucus, while the lever lip has been quite dry: the one has thus been shown to be receptive, and the other not. The author says he has the support of Mr. Charles Darwin in saying that this peculiar structure is thus apparently correctly explained.*

The Stromatoporidæ.—Mr. H. J. Carter continues the discussion on this subject in the October number of the 'Annals,' under the title "The probable nature of the Animal which produced the *Stromatoporidæ* traced through *Hydractinia*, *Millepora alcicornis*, and *Cannopora* to *Stromatopora*," and in which the views of Dr. Dawson † and of Professor Nicholson and Dr. Murie ‡ are criticized, the latter article, however, being referred to as a "valuable and welcome contribution."

Structure of Blood-corpuscles.—At the "Physiological Laboratory," University of Michigan, Dr. C. H. Stowell has continued his study on the structure of the red blood-corpuscles.

The method employed is that given by Professor Bœttcher in the 'Archiv für Mik. Anat.,' vol. iv. §

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* 'Journal of the Linnean Society' (Bot.), vol. xvii. p. 145.

† See p. 208.

‡ See p. 285.

§ 'M. M. J.' vol. xviii. p. 242.

The July number of 'New Preparations' contains the following account of recent experiments. Dr. Stowell says:—

My experiments were performed on cats and rats, poisoning them with solutions of corrosive sublimate—in some cases bringing on death immediately, in others not until the lapse of several days. The blood was examined both before and after death, and no change was discerned in the appearance of the blood-corpuscles, except in a few instances, when there was noticed some change in their shape. This is not what one would anticipate from a perusal of Professor Bœttcher's article.

However, by following the method given in the last number of your Journal, we have demonstrated this nucleus in the red corpuscle of man (as previously reported), the dog, cat, and rat. The most satisfactory result was obtained from the blood of the rat; the most unsatisfactory from that of a man. No value, however is attached to this fact.

By using higher powers than at first employed, we are positive there is a granular appearance to this nucleus, not present in other parts of the blood-cell. In some cases this is quite marked, especially when the nucleus is large; and also in those corpuscles where we have seen a nucleolus, this granular structure is very evident. This is what we should expect when accepting Beale's theory of protoplasmic matter.

In some specimens examined, the proportion of nucleated to non-nucleated cells was very small indeed, while in other specimens the proportion was much greater.*

Is there a Science of Microscopy?—"To the student of natural science the microscope is, and always will be a mere tool. Microscopy, as a special science, has very little claim for existence. In so far as a certain familiarity with the instrument, and training in the proper management of the light and accessories, are necessary to enable one to use the instrument, it may be called a science. We should detract nothing from the merits of those who are expert in securing the most perfect performance of an objective.

Still, as a matter of fact—and plain facts should not give offence to anyone—we must admit that the great value of the microscope, as a means of investigation, lies in the aid it gives to almost every branch of science.

This leads us to a statement of what, in our opinion, a microscopical journal should be. Recognizing the value of microscopical study in the various branches of natural science, such a journal should aim to publish the results of research carried on with the microscope in every department.

This opens a wide field, and demands the attention of the naturalist, the physician, the lithologist, and the botanist, of all, in fact, whose study leads them to examine minute structure, and there are few indeed, at the present day, who find no use for a microscope. While we so plainly deny the claims of microscopy to the position of

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* 'American Quarterly Microscopical Journal,' vol. i. p. 46.

a science, at the present day, we as strongly urge its claims as an invaluable adjunct in many studies.

Surely it has revealed isolated facts in structure and growth, it has created the sciences of biology and embryology, it has added much to our knowledge of morphology, and become of incalculable benefit to the physiologist and practising physician; and yet, of what real value would all its revelations be to us, without the systematic grouping of facts and knowledge which comes with the development of these sciences; some of which, indeed, the microscope has helped to create?" *

This is one view of the question. It is intended in the next number to give a translation of Dr. Ed. Kaiser's article on the same subject in the last number of the Berlin 'Zeitschrift für Mikroskopie.'

On a rare Form of the Hepatic Organ in the Worms.—In the generality of worms the liver, represented by a cellular layer attached to the intestinal wall, and covering it to a greater or less extent, appears to differ fundamentally from the same organ in the Mollusca, Crustacea, &c.

The examination of certain types shows, however, that this distinction is far from being as absolute as might at first be thought, and in some of the Annelida, belonging to the genus Hirudo, or Chætopoda, the biliary secretion has a tendency to localize itself in small cæca inserted on the margins of the intestinal canal; but these cases, which nearly always coincide with peculiar conditions of the digestive tube, are too rare and too imperfect to show an actual morphological relationship with the arrangements peculiar to the higher Invertebrata. The latter, on the contrary, were found, in all their essential characteristics, in a Helminth which I recently had an opportunity of examining, and the observation of which proved most instructive in this respect.

This Nematoid, belonging to the Agamonemæ, was seen by Dies encysted in the muscles of various fishes, and was sent to me by M. H. Filhol, who collected many specimens of them during his stay in Campbell Island. In this species the initial or œsophageal region of the digestive tube is somewhat slender, and presents no other glands but small follicles of irregular shape containing a viscid hyaline fluid studded with fine greyish granulations.

The middle intestine which immediately succeeds, is readily recognized by the inequality between its diameter and that of the preceding portion; this difference is owing less to a sensible increase in the calibre of the intestinal tube than to the development of an external mass of a brownish colour which surrounds it and appears to be blended with it.

If this mass is teased and viewed with an amplification of $\frac{120}{1}$, and then of $\frac{350}{1}$, it will be evident that it is formed of glandular tissue. It is composed, in fact, of a multitude of culs-de-sac bounded by a fine membrane, which becomes slightly thicker at the periphery. In their interior are seen a great number of rounded granulations brownish or

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* 'American Quarterly Microscopical Journal,' vol. i. p. 58.

yellowish in colour; the absence of epithelial elements is easily explained by the state of the animal.

The structure of the organ recalling, in all its principal features, the constitution of the liver of the Crustacea and Mollusca; its affinities resembling those which it affects in certain of them (Squilla, &c.), oblige us to regard it as a new form in the worms, and show that if the majority of these animals deviate in this respect from the other Invertebrata, there are some which deserve to be classed with them and possess like them a true hepatic gland.*

The Sting of the Honey Bee.—The new 'American Quarterly Microscopical Journal' commences with an article by Mr. J. D. Hyatt, of 11 pages (with 2 plates), on this object, which the author describes as one which "our naturalists have either imperfectly understood or else the records of their knowledge are so concealed in voluminous reports of scientific societies as to be practically inaccessible to the amateur microscopist.

It is true that we have in most of our books that treat of microscopic objects, a general description of this mechanism, and if we go to the head waters and consult such original investigators as Burmeister, Westwood, and numerous others, but above all the admirable researches of M. Lacaze-Duthiers, we shall greatly extend our knowledge. Yet after having, at great expenditure of time, consulted all these and many other works, we may come back to our slide containing the dissected sting, and still find an inexplicable mystery in some of its parts. This has been my experience, and with a view of determining more accurately the entire mechanism of this intricate and complicated structure, I have carefully observed its action, so far as possible in the living insect, and by numerous dissections, in which I have traced every point of connection of the various pieces, and tested every possible movement of the parts upon each other, and made transverse sections through every point in its entire length. I now venture to place before you the result of my investigations."† The article cannot unfortunately be usefully abstracted, and we can only refer to the Journal itself, of which a copy is in the library.

New Diatoms.—Mr. F. Kitton sends the following:—

Melosira Borreri (Grev.), var. *hispida*, Castracane. This variety is distinguished from the type by the presence of teeth or short spines scattered over the surface of the valve, and more especially at the base of the convex part of the frustule. Canal de Trau, *Dalmatia*.

CYCLOPHORA TENUIS, Nov. Gen., Nov. Sp., of M. De Castracane.

Cyclophora, n. g.—Frustula tabulata, rectangula vel in fascias conjuncta, vel soluta, vel isthmo gelineo alternatim conjuncta, a fronte oblonga linearia, vel parum inflata; valvis inæqualibus, quarum una

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* M. Joannes Chatin, in 'Comptes Rendus,' vol. lxxxvi. p. 974.

† 'American Quarterly Microscopical Journal,' vol. i. p. 3.

annulo vel loculo centrali instructa. Individua vivunt in aqua marina.

C. tenuis, n. s.—Frustula a latere oblongo-rectangula, medio tumidula; valvis lineari-inflatis, polis rotundatis; una valvarum loculo centrali rotundo instructa, in sectione subquadrato. *Long. valvarum*, 44 μ 5–55 μ 2; *lat.* 4 μ 8–11 μ 3. Habitat—Anconæ ad scopulum Ste. Clementis, Neapolim in aquario.

(*Atti della Accad. Pontif.*, 1878, 2ª sess.: extracted from BREBISSONIA, No. 2, 1878—a new illustrated monthly serial devoted to Algology and Micrographic Botany, edited by M. G. Huberson.)

The 'American Quarterly Microscopical Journal' * also contains figures and descriptions by Professor H. L. Smith of the following new diatoms (all n. sp. H. L. S.):—

Homœocladia capitata.—Black Rock, Cal.
Meridion intermedium.—Knoxville, Tenn.
Navicula Kutzingiana.—Avranches, Normandy.
Navicula parvula.—Villerville (France).
Nitzschia Kittoni.—River Catuche, Caracas, Venezuela.
Raphoneis australis.—Royal Sound, Kergueland's Land.
Rhizosolenia Eriensis.—Lake Erie, Lake Michigan.
Cestodiscus Baileyi.—Lower Lake, Klamath.
Amphora mucronata.—Atlantic Marshes, Cape May, N.J.
Actinocyclus Niagaræ.—Lake Erie.

In regard to the last species, the author says that its occurrence in fresh water is sufficiently remarkable, as all the members of the genus hitherto known are marine, and he concludes that it is one of those diatoms living at considerable depths, and which are only brought up by dredging or storms. That diatoms flourish in immense abundance—notably, the *Coscinodisceæ*—at great depths is indicated by many of the 'Tuscarora' soundings; some of these, from depths of over three miles, were almost wholly *Coscinodiscus omphalanthus* and its varieties, fully charged with endochrome; and belts of "diatom ooze" at considerable depths were also found by the 'Challenger' naturalists.

Kutzing's Diatomaceæ.—In regard to *N. Kutzingiana*, Professor Hamilton Smith says:—"I give to it the name of the celebrated algologist, Kutzing, whose numerous figures of Diatomaceæ, though but mere outlines sketched by aid of a microscope that would scarcely be looked at, much less through, at the present day, possess more of the character and catch more of the spirit of the living species than many of the representations of modern days, and whose descriptions are models of accuracy and conciseness. The more I study his plates, the more I admire their conscientious accuracy and faithfulness."

Collecting Copepoda. — A few words as to the best modes of collecting Copepoda is given in Dr. G. S. Brady's "Monograph of the Free and Semi-parasitic Copepoda of the British Islands." †

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* Vol. i. p. 12.

† Printed for the Ray Society, 1878.

"In the case of tidal marine pools and small fresh-water ponds, such as may easily be fished from the edge, a common ring net fitted with a muslin bag and attached to the end of a walking-stick will answer every purpose. This may be worked to and fro amongst the weeds or in the clear water, and the results, when cleared from coarse debris and extraneous materials, may either be put at once into spirit, or, if it is wished to keep the Entomostraca alive, into water, fresh or salt, as the case may be. Marine surface-swimmers may be taken in a similar way by working the net from the side of a boat, or a tow net may be thrown over and attached to the boat by a cord. A tow net put overboard from a vessel anchored for the night in a tideway will often be found in the morning to have made good captures. And it may be noted that surface net gatherings made during the hours of dusk or darkness are commonly of much greater interest than those taken in daytime; it seems certain that many marine Crustacea which are found near the surface at night recede towards the bottom on the approach of daylight. . . . The washing of fronds and roots of Laminariæ, which may be dragged up by means of the hooked grapnels used on many coasts by kelp-burners, often affords multitudes of Copepoda. The weeds should be washed by agitation in a large tub of sea-water, and when the operation is completed, the water, after being allowed sufficient time—a few seconds only—for the subsidence of coarse material, is to be poured off through a muslin net, on which the Copepoda, and probably numerous other swimming animalcula, will be intercepted. These may be cleaned while in the net by repeated douches of sea-water. The products of the dredge, sand, mud, gravel, shells, &c., should be treated in a similar manner before being thrown overboard. I have no doubt that this method of procedure offers by far the best chance of extended acquaintance with microscopic life of the sea-bed, and that numberless new species and interesting forms of life may be discovered by its means.

The preservation of specimens is probably best effected by alcohol in the form of rectified or methylated spirit, but this agent has the disadvantages of destroying many colours, and of rendering the animals opaque by coagulating their albuminous tissues. Still, among the numerous solutions which have from time to time been recommended, none are on the whole so convenient or efficient. Perhaps the next best is a solution of chloral hydrate (twelve grains to a fluid ounce) in camphor water. As microscopic preparations, Copepoda are best mounted in some gelatinous medium containing a very small quantity of glycerine. Treated in this way, mountings will keep in perfect condition for many years—eternally for anything I know to the contrary—without the trouble of cementing round the edges of the glass cover. Before dissecting Copepoda for microscopic examination, they should be macerated for a few hours in a solution of caustic potash; the fatty and granular tissues are by this means removed and the details of structure rendered clearly visible; the dissection is easily performed under the microscope with fine needles, either with or without the help of an erector."

Zeiss's New $\frac{1}{12}$ Oil-immersion Objective.—Mr. A. Schulze "finds the optical qualities of this new lens in every respect equal to that of the $\frac{1}{8}$, the angular aperture being about the same. The working distance is about one-thirtieth inch, and the magnifying power with a Ross A eye-piece fully 580 diameters. The field is perfectly flat, and the brilliancy and definition leave nothing to be desired, whilst the resolving power is extraordinary. All the finer diatomaceous tests, such as *Amphipleura pellucida*, &c., are resolved with the greatest ease and with the utmost distinctness; and although I have hitherto failed to see both with the $\frac{1}{8}$ and the $\frac{1}{12}$ oil-immersion lenses more than with Powell and Lealand's excellent new formula, or some other first-class water-immersion lenses, yet I see everything better and easier than with the latter. For the resolution of the markings on diatoms no better lenses could be desired than these oil-immersion lenses. . . . It is to be regretted that Professor Abbe and Mr. Zeiss deem it inadvisable to undertake the construction of microscopical objectives of yet higher power on the oil-immersion principle. This they do, however, both on account of practical difficulties in the production of still smaller lenses, and because no greater angular aperture could be gained than those of the ordinary largest angled water-immersion lenses." *

Theory of the Action of Bacteria in Anthrax.—In applying the data furnished by the experiments communicated to the Academy to the comparative study of the lesions which I have observed in different species of animals, I consider that it is possible to deduce from them a general theory of the action of bacteria introduced into an organism. The following is a summary of the theory:—

Anthrax is due to the existence of a parasite which lives and is reproduced in the blood and fluids of living animals, which acts through its physical qualities, and through the substances which it secretes or exudes, or the formation of which it provokes; these substances are soluble, and possess inflammatory properties more or less intense according to the animals which nourish the bacteria. The difference in activity of the phlogogenic matter has not yet been explained: it is possible that it depends on the peculiar properties of the blood of the animals in which the parasites are developed, but some experiments, unpublished as yet, lead me to think that they may be owing to polymorphism.

When the bacteria produce a matter which is only slightly inflammatory, they act more especially by their physical properties, and cause death by the obliteration of the capillary vessels of the essential organs; such is the case with the rabbit, the sheep, and the guinea-pig, where these lesions are almost exclusively met with. To the more intense phlogogenic properties correspond vascular lesions of another order; the rupture of the capillary vessels and effusions of blood more or less considerable which exist simultaneously with the vascular obliterations, as is seen sometimes in sheep, and always in the horse and the ass. Lastly, the inflammatory properties may predominate, and

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* 'English Mechanic,' vol. xxviii. p. 144.

death take place, when the number of the bacteria is relatively inconsiderable; the vascular ruptures then become of extreme importance; they are found especially in the walls of the heart of the dog.

It now remains, in order to complete this theory, to examine and explain the lesions of the lymphatic system. The following are the facts which have been derived from my experiments:

Three cases are possible:

1. The Anthrax was transmitted by *inoculation* to an animal which died without showing vascular ruptures.
2. The Anthrax was transmitted to the animal by *injection* direct into a vessel.
3. The Anthrax was transmitted either by inoculation or by intravascular injection to an animal which in the course of the malady showed more or less numerous vascular ruptures.

In the first case researches made on the fresh or hardened ganglia and by means of sections, showed no bacteria except in those situated in the course of the lymphatics, proceeding from the inoculated spot, where they were found in immense numbers.

In the second case no ganglion showed the presence of bacteria in the sinus; the only ones met with were contained in the blood-vessels of the follicles.

In the third case all the ganglia situated in the course of the lymphatics, proceeding from the points where the vascular ruptures existed, were gorged with bacteria; the infiltrations in the neighbourhood of the rupture showed heaps of them, formed of long entangled filaments, and the ganglia had a quantity of them in their sinus, which augmented with the age of the rupture.

These three cases are easily interpreted; they are reducible, in fact, to one. The mode of action of the bacteria is always the same. Take the first (that of inoculation) as a typical case.

When an animal has been inoculated, from that moment until its death it constantly shows the presence of bacteria in one or other parts of its economy—not latent bacteria in the state of the germ, but entire and articulated, and visible to the microscope. They are always found in the connective tissue adjacent to the inoculated spot, and their number is greater in proportion as the period of inoculation is distant from that of observation. The infiltration or œdema which they provoke, is propagated in the direction of the lymphatics which collect and convey them to the ganglion. They penetrate this organ, as do all finely pulverized solid substances, as red-lead injected under the skin and tattoo powders; I have found them in considerable numbers (about ten in the field of the microscope), five hours after an inoculation has been made, at two centimetres distance from an axillary ganglion, in the pulp of this ganglion. Once in a ganglion they multiply, produce inflammation, and a more ready discharge of the substances inclosed in the lymphatic sinus; their multiplication by elongation is also a mode of progression; they finally issue forth through the efferent vessels and reach the following ganglion, or rather the blood-vessels, where they multiply rapidly and where they remain.

From the instant that the bacteria penetrate into the blood (by taking the blood of a rabbit inoculated 7½ hours previously from three punctures made in the inside surface of each fore-leg, and injecting fifteen drops of it in the jugular of another rabbit, I caused the death of the latter) the phenomena are as though the injection had been made in the vessels, that is, as in the second case, allowance being made for the parasites constantly supplied by the ganglia which were the first receptacles.

Finally, in the case in which vascular ruptures supervene after the penetration of the bacteria into the blood, each rupture lets a greater or less number of bacteria escape, which there act as true, deep inoculations, which are followed by the same disorders as in subcutaneous inoculation, that is to say, infiltration, penetration into the ganglia, and return to the blood. But the disorders in this case are so numerous and severe that the animal dies before the capillary emboli are formed.

The knowledge of these facts may throw some light on the mode in which the bacteria penetrate in the case of spontaneous Anthrax; it enables us to determine in what part of the economy and through what channel the parasites are introduced.*

Onchopora hirsuta.—Mr. W. H. Weightman, of the Liverpool Microscropical Society, has shown that, besides the common tubes, described and figured by Mr. Busk in the 'Quarterly Journal of Microscopical Science' for 1855, there are also at the base of the lowest internode a number of radical tubes, which Mr. Busk seems to have overlooked. They are each upwards of one-tenth of an inch in length, hollow like the others, but spirally twisted, and not jointed. The extremity of each of these radical tubes is dilated, and of a crozier-like form, and of a much darker colour than the shaft. Within the crozier-like tip there appears to be a dark secretion, which in the living condition was probably fluid, but the purpose of which he is quite ignorant of.

The calcareous cell of Onchopora is somewhat granular in substance, and is minutely punctured, and acts with some degree of energy on polarized light, but not so much so as the corneous tubes, which are quite brilliant when viewed with polarized light; the radical tubes are somewhat less so.

Spore Nomenclature.—In regard to an article on this subject in the 'Bot. Zeitung,' by Messrs. A. de Bary and E. Strasbürger, the 'Bulletin' of the French Botanical Society (vol. xxv. p. 32) says:—"The *Acetabularia* furnishes a new example of conjugation between zoospores, interesting because of the terminology it gives the authors an opportunity of proposing. The biciliated and sexual antherozoids which are capable of copulation receive from them the name of '*gametes*,' and the products of their copulation that of '*zygote*,' instead of isospore or zygospore. They are anxious to remove from this name the root-*spore*, reserving this term for the reproductive body which does not result from a fecundation."

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* M. Toussaint, in 'Comptes Rendus,' vol. lxxxvi. p. 978.

The Causes of Buzzing in Insects.—The number of 'Comptes Rendus' for 7th October last * contains a note by M. Jousset de Bellesme on M. Perez's paper on this subject which appeared in an earlier number, and which is translated at p. 276. The note is in substance identical with that which is quoted from the 'Times' at p. 278, and as, although somewhat more precise, it includes no additional facts, it is unnecessary to reproduce it here. A translation appears in 'Annals and Mag. of Nat. Hist.' for November.

The Germ Hypothesis of Putrefaction.—Dr. B. W. Richardson, F.R.S., delivered during the present year at the Society of Arts a series of six (Cantor) Lectures on "Putrefactive Changes and on the Preservation of Animal Substances." The lectures concluded with a reference to the Germ Hypothesis, of which the following is an abstract:—

This has been very differently treated by different authors. On one side it has been subjected to derision, on the other extolled to childish adulation. It may be said to have started with the observation of Redi, that the exclusion of dead animal matter from something in the air, which could apparently be filtered out of the air, arrests putrefactive change as it might arrest the introduction of the ova or germs of other living forms in the same substance. We have seen in our experiments that exclusion of air does, for a time, under some circumstances, interfere with commencing putrefaction.

This looks like truthful demonstration. Yet still it is a very easy thing to oppose the hypothesis altogether. We can show, that animal tissue decomposes in the closest chamber; when imbedded in hard paraffin; when coal-gas or other negative gas takes the place of air. All these facts indicate that air is not wanted either to act itself, or to convey particles or germs.

But it may be urged on the side of the hypothesis, that the dead animal substances, before the time when they were subjected to these exclusive tests, had been exposed to the infection of germs.

To this there is an experimental answer. Here are specimens which after having been subjected to the air itself, under pressure, had not decomposed; and others which have been exposed to the air, but because they are charged with a small part of a salt, or gas, or vapour, have not decomposed. Thus a substance may be exposed to the air and may not change. All our salted provisions may be used as arguments in support of this truth.

There will again be a ready answer to suit the hypothesis, namely, that under such conditions germs cannot live. The conditions are fatal to life in any form. How can germs live in cyanogen, or sulphurous acid, or under atmospheric pressure, beyond what is natural?

The answers are plausible, and the germ hypothesis might be defended possibly on them if there was nothing else to be said. But there is more behind. We can arrest life in action and still have decomposition. If I were to put a firm ligature round one of my limbs, and so completely cut off the supply of blood, I should do the

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* Vol. lxxxvii. p. 535.

most effectual thing for cutting off the supply of germs into that limb, if germs really do enter it. Thereby, I ought to stop decomposition of that limb, for I have cut off both oxygen and blood from it. Nevertheless, the muscles of the limb will of a certainty decompose. My explanation why the limb decomposes, under those circumstances, is clear enough. I would say that I have left the water of the tissue subjected to agents in the blood itself, fibrine, and blood-cells, which are alone sufficient to decompose the water of the tissues, and that as I have cut off the supply of blood that was entering the limb, the liberated hydrogen, in the nascent state, combines with the nitrogen and other elements of the nitrogenous textures, and sets up the series of decompositions—or re-compositions—called putrefactive changes.

Is there, then, no truth at all in the germ hypothesis? There is, I think, a germ of truth. I believe it is probable, from the two circumstances, that filtration of air does, in some structures, check putrefactive change, and that in these instances new forms of life are developed. From these two circumstances it is, I repeat, probable that there may exist in the air minute organic particles which, coming into contact with the water of collodial structures and fluids, are capable, like fibrine and blood-cells, of starting the decomposition of water, and so exciting putrefaction. Germinal particles may thus be added to other and much more abundant materials capable of exciting the change. This is all I have to say, from what I have seen, in support of the germ hypothesis; and indeed, in saying so much I am rather acknowledging certain facts which, at this moment, do not admit of other explanation, than putting forth an affirmative opinion.*

"*Hullite.*"—At the Dublin Meeting of the British Association, Mr. E. T. Hardman, F.C.S., read a paper on this hitherto undescribed mineral, which occurs in abundance near Belfast, in the basalt forming the neck of a Miocene volcano. The author proposed to call it Hullite, after Professor Hull, in commemoration of the valuable work he has done in elucidating the microscopic mineralogy of the basalts of Ireland. Professor Hull has examined the microscopic structure of the mineral and of the rock in which it occurs, and has described the appearance presented by the mineral. Under the microscope it is of an amber-brown colour, nearly opaque. It permeates the whole rock, filling the interstices, and enclosing the other minerals. It appears very much to assume the character of chlorite, and is undoubtedly a distinct mineral, and not a product of alteration.

The Revivification of Diatoms.—Referring to the communication of M. Petit (see p. 26) to the French Botanical Society, M. Bureau reminded the Society that some plants relatively high in organization, such as certain species of *Selaginella* and Ferns, were capable of being revivified after a prolonged desiccation in an oven heated to 60° C. He had made experiments which left no doubt on the subject.

M. Duchartre observed that a distinction must be made between the experiments of M. Bureau and those of M. Petit on the Diatomaceæ. It appeared to him, according to M. Petit's communication, that it is

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* 'Journal of the Society of Arts,' vol. xxvi. p. 971.

necessary, in order that the diatoms should be desiccated without perishing, that they should be enveloped in the mud, and that consequently the desiccation of these Algæ does not take place in the open air. M. Petit replied that that was in effect his opinion, and that he had remarked in the course of his observations that all the diatoms which were in the open air without the intermediary of a protecting body to retard the desiccation were dead, and that all his efforts to recall them to life were in vain.*

The Diatomaceæ of the Arctic Expedition.—Dr. Dickie reports in the 'Journal of the Linnean Society' (No. 98, Bot.) on the Algæ collected during the last Arctic Expedition, by Captain Feilden, Dr. Moss, and Mr. Hart, beyond lat. 78° N., including the Diatomaceæ. The localities where they were gathered are first given in numbered series, after which comes a list of all the genera and species, with numbers corresponding to the localities attached. This saves needless repetition, is available for data concerning distribution, and at a glance shows paucity or frequency of genera and species.

The Diatomaceæ observed represent thirty-one genera, and amount to seventy species; most of them are marine, the fresh-water species being few in number. The presence of these minute organisms, with their exquisitely sculptured siliceous investments, is a point of much interest in relation to the presence of certain forms of animal life. Dr. Dickie has repeatedly received masses of such, resembling pieces of fat or of sodden bread, from ice-floes in various parts of the Arctic Sea; and in the alimentary canal of bivalve Mollusca from the same quarter preserved in spirits, he has found abundance of marine diatoms.

Where these occur (and they are generally plentiful) this implies the possible presence of animal life, the lower forms of which are preyed upon by the higher; and thus we have a very notable and interesting chain of dependence. It is not, therefore, a matter for surprise that sixteen species of bivalves were collected beyond 80° N. by the naturalists of the Expedition.

P. T. Cleve, in a communication to the Swedish Academy of Sciences in 1873, states that the entire number of diatoms found in the Arctic Sea is 181; the species already enumerated, excluding the twelve freshwater, amount to about one-third. From the same paper it would appear that those found near Spitzbergen are far more numerous than those now recorded.

Melicerta ringens.—Mr. F. A. Bedwell has re-examined the mastax with the $\frac{1}{8}$ oil-immersion. His letter to the Secretary will be found with the 'Proceedings,' p. 391.

The $\frac{1}{8}$ Oil-Immersion Objective.—Professor Hamilton Smith contributes an article on the $\frac{1}{8}$ to the 'American Quarterly Microscopical Journal.' He "has no hesitation in saying, and all who have looked through it agree with him, that up to this time it is the best foreign-made objective he has seen;" but, whilst "begging not to be understood as depreciating it," he maintains, however, that a $\frac{1}{10}$ and

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* 'Bull. de la Soc. Bot. de France,' vol. xxiv. p. 369.

† 'American Quar. Mic. Journal,' vol. i. p. 28.

$\frac{1}{6}$ of Spencer (used with glycerine for very oblique, and with water for axial illumination) "were manifestly superior, not only showing the markings of *Amphipleura pellucida* blacker and finer, but standing better the test of deepest eye-pieces without flinching."

Botrydium granulatum.—The *Botrydium granulatum*, which inhabits the clayey mud on the borders of ponds, is composed of an aerial part, globular, green, and the size of a pin's head, and of a subterranean rhizoid part, which is only an attenuated prolongation, ramified by dichotomy of the globular aerial cell. This latter alone contains chlorophyll. Transferred to a drop of water, it gives birth to numerous asexual zoospores, furnished at their extremity with a single vibratile cilium, and capable of immediate germination.

But, on the contrary, when the atmosphere is dry, this sporangium shrivels up and empties itself; its protoplasm passes into the root-like apparatus, where it collects into little masses, each of which is surrounded by a membrane, and it is then in these cells of accidental formation (subterranean zoosporangia) that the zoospores are formed. In other cases, there appears on a point of the root-like system a vesicle which rises above the surface of the ground, and which is capable of living all the year, and even of undergoing a period of desiccation, before producing these zoospores. This vesicle (hypnosporangium) is rounded; it is this to which has been given the name of *Botrydium Wallrothii.*

Under other influences, and chiefly under that of direct exposure to the sun, the contents of the aerial organ of *Botrydium* may break up into a certain number of cells, furnished with membranes,* whose colour, green at first, may be transformed later on into a fine red. These cells, when liberated, give birth to numerous biciliated zoospores; these last can reproduce the individual only after a copulation similar to that which M. Pringsheim has described in the *Pandorina Morum*, and after being fused in pairs into isospores.†

The Life-History of Filaria Bancrofti.—Dr. T. Spencer Cobbold, F.R.S., devotes a paper to this organism, which he terms "one of the most remarkable parasites that has ever engaged the attention of helminthologists." The paper firsts shows the steps by which we have acquired our present knowledge, through the discoveries of Wucherer, Lewis, Bancroft, Manson, Sonsino, the author, and others. What that knowledge actually expresses when summarized in the lowest possible number of convenient terms is stated in the following six "propositions":—

1. *Filaria Bancrofti* is the sexually mature state of certain microscopic worms hitherto obtained either directly or indirectly from human blood.

2. The minute hæmatozoa in question, hitherto described as Wucherer's *Filariæ*, *Filaria sanguinis hominis*, *Trichina cystica*, *Filaria*

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* These are the cells which have been described under the name of *Protococcus coccoma*, *P. palustris*, *P. botrydioides.*

† Review of MM. Rostafinsky and Woronin's paper (published in Leipzig), 'Bull. de la Soc. Botanique de France,' vol. xxv. p. 14.

dermathemica, and so forth, are frequently associated with the presence of certain more or less well-marked diseases of warm climates.

3. The diseases referred to include chyluria, intertropical endemic hæmaturia, varix elephantiasis, lymph-scrotum, and lymphoid affections generally, a growth called *Helminthoma elastica*, a cutaneous disorder called craw craw, and also not improbably leprosy itself.

4. It is extremely probable that a large proportion, or at least that certain varieties of these affections are due to morbid changes exclusively resulting from the presence of *Filaria Bancrofti* or its progeny within the human body.

5. It is certain that the microscopic hæmatozoa may be readily transferred to the stomach of the blood-sucking insects, and it has been further demonstrated that the digestive organs of the mosquito form a suitable territory for the further growth and metamorphosis of the larval *Filariæ*.

6. The character of the changes undergone by the microscopic *Filariæ* and the ultimate form assumed by the larvæ whilst still within the body of the intermediate host (*Culex mosquito*), are amply sufficient to establish the genetic relationship as between the embryonal *Filaria sanguinis hominis*, the stomachal *Filariæ* of the mosquito, and the sexually mature *Filaria Bancrofti*."

Dealing with the practical consequences which may be expected to flow from a fuller recognition of the importance of this *Filaria*, the author points out that a consideration of the highest value in relation to epidemiology generally, and more especially in regard to the practical question as to the best methods of stamping out parasitic plagues, is that which refers to the life-history of the entozoon itself. It must be obvious that in all cases where the intermediate host can be captured and destroyed, the life cycle of the parasite can be broken or interrupted; and if thus broken there is an end to the further propagation of the species. The knowledge that we have acquired by experimental research in this direction has already enabled us to set a limit upon the prevalence of certain well-known disorders, such as trichinosis, cestode tuberculosis, and so forth. In the case of epizootics, however, which are not merely dependent upon minute entozoa, but which are also, in the way that we have seen, indirectly due to the action of intermediary hosts that cannot be readily captured or destroyed, our power of arresting the disease is comparatively limited. In the case of *Filaria Bancrofti* it is probably not necessary either that a dead or living mosquito should be swallowed to ensure infection; but it is necessary that the parasitic larvæ should have dwelt within the mosquito in order to arrive at the highest stage of larval growth prior to their re-entrance within the human territory. Undoubtedly the larvæ of *Filaria Bancrofti* are swallowed with potable waters. The perfect filtration of these waters before use would certainly check, and in course of time would probably cause the total extinction of several of the many virulent diseases that now afflict the inhabitants of warm climates.*

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* 'Journal of the Linnean Society' (Zool.), vol. xiv. p. 356.

Oleomargarine.—A controversy has been recently raging at New York in regard to the qualities of this substance, between Mr. John Michels and some correspondents of the 'New York Times.' In an article in the 'American Journal of Microscopy,' for October, Mr. Michels writes:—

"Having observed paragraphs in various medical and scientific journals, stating that oleomargarine could not be distinguished by the microscope from butter, and suggesting various chemical methods to meet the difficulty, I was prompted to purchase samples of these substances, and make a careful microscopical examination of them.

The result of my examination was very decisive, and just what I expected; namely, that the oleomargarine was loaded with free stellate or feathery crystals, and that the butter presented the uniform appearance of fat-globules so often described in handbooks, and perfectly free from any crystalline forms except those of chloride of sodium or common salt.

I examined a large number of samples under different temperatures, and under a variety of conditions, but the results here shown * are from two samples examined just as they were purchased, pressed out to a fine film in the usual manner, under a thin cover, and examined with a four-tenth objective by Beck.

During some months I always found the same results, but discovered that by a trick and by manipulating the samples, the butter could be made to show a field full of crystals, and the oleomargarine free from them; but examine true samples of either in their normal condition, and the results I have shown will always be observed.

As I have stated, my examination of oleomargarine extended over some months, during which period I invariably found that each sample contained cells of a very suspicious character, with fragments of tissue and muscle. This led me to investigate the process of manufacture, and I then found that during the whole process from first to last, the animal fat, &c., of which this substance is made, is never subjected to a higher temperature than 120° F.

It at once occurred to me, that taking into account the well-known thermal death-point of certain organisms frequently found in animals, which, although diseased, are regarded by dealers as fit for food, such a temperature of 120° F. was totally insufficient to destroy the germs of even the adult individuals of such forms of life.

Again, the original French patent states that the stomachs of two pigs or sheep should be chopped up with a certain amount of fat, on account of the pepsine there contained, and I found that this practice was in use in the New York oleomargarine manufactories. For these reasons I conclude that oleomargarine thus manufactured is not a safe or wholesome article of food, and I assert that, however disguised it may be in appearance, oleomargarine as offered for sale, is nothing but raw fat, liquefied, scented, coloured and flavoured to give it a spurious appearance of butter, and that those who use it run the risk of trichinæ, from the stomachs of pigs chopped up with the fat, and

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* Two woodcuts—one showing the usual appearance of fat-globules, the other stellate or feathery crystals.

that infection from certain contagious diseases, which are common to man and the domestic animals, might follow."

The opposition which these views encountered is then referred to, particularly that of Professor J. W. S. Arnold, of the University of New York, who stated that he had examined with the microscope the two substances, and found their "optical appearance alike," which is accounted for, according to Mr. Michels, by the Professor having allowed the oleomargarine manufactory to prepare the specimen examined.

A letter from the Rev. W. H. Dallinger as to a temperature of 120° F. not being permanently injurious even to adult forms of putrefactive organisms is given, and Mr. Michels concludes by referring to "the following independent confirmation, which was published in the 'Scientific American,' giving the result of the appearance of butter and oleomargarine under the microscope, by Mr. Thomas Taylor, Microscopist of the Department of Agriculture at Washington.

Mr. Taylor reports that when pure dairy butter is viewed under the microscope, the forms consist of oil-globules, and the crystals of common salt; when a specimen of oleomargarine was examined in the same manner, the field was speckled over with shiny particles, and it was demonstrated that these glistening particles were crystals of fat. In using a power of 250 diameters, animal tissue is seen more or less all over the field. One specimen of oleomargarine was highly charged with animal tissue and crystals of urate of magnesia, showing the fat used in this case to have been impure, which would seem to prove that the assertions made by the oleomargarine manufacturers as to the perfect purity of the fats used by them, are not altogether correct.

From this it would appear that oleomargarine may be easily known from butter by the aid of the microscope, and that any impurities in the fats of which it may be composed may be readily detected."

Microscopical Slides of Lichens.—The intended issue is announced (by Messrs. Joshua and Holmes) of a series of microscopical slides, illustrating the principal families, genera and sub-genera of lichens, to be followed by a series of specimens of lichens of which no figures have been published. The specimens are to be as typical as can be procured, and will consist of sections of the apothecia, showing all the various parts.

Limits of Microscopic Vision.—Extracts from a letter from Professor Stokes, Sec. R.S., as to Fraunhofer's formula, and one from Mr. J. Mayall, jun., will be found with the discussion on Dr. Pigott's paper, in the 'Proceedings,' at p. 389.

Pygidium of Insects.—The discussion at the November meeting on this subject will also be found in the 'Proceedings,' at p. 390.

Raphidiophrys pallida.—A note by Professor E. Ray Lankester on this Rhizopod (new to this country) will be found at p. 393.

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ANNALS AND MAGAZINE OF NATURAL HISTORY. Fifth Series, Vol. II., No. 11 (for November):—

On the Structure and Affinities of the Genus *Catagma*. By W. J. Sollas, M.A., F.G.S., &c. (With a plate.)

Studies on Fossil Sponges. II. *Lithistidæ*. By Karl Alfred Zittel. (*Continued.*)

Miscellaneous. — The Nauplius Stage of Prawns. By Fritz Müller and C. Spence Bate.—Amphipoda in Sponges. By the Rev. T. R. R. Stebbing, M.A.—On the Oviposition of the Queen Bee and Dzierzon's Theory. By M. J. Pérez. (From 'Comptes Rendus.')—On the Cause of Buzzing in Insects. By M. Jousset de Bellesme. (From 'Comptes Rendus.')—On the Ascarides of the Seals and Toothed Whales. By Dr. H. Krabbe. (From 'Oversigt af Kongl. Danske Vidensk. Selsk. Forhandl.,' i. Aaret, 1878.)

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GREVILLEA (No. 42) for December:—

New Diatoms. By Professor H. L. Smith, LL.D. (From 'Am. Quar. Mic. Jour.')

Rehm's Ascomyceten.

New Diatoms. By Professor P. T. Cleve. With notes by F. Kitton, Hon. F.R.M S.

Californian Sphæriæ. By Charles B. Plowright.

Cryptogamic Literature.

HARDWICKE'S SCIENCE-GOSSIP for November:—

Fossil Polyzoa. The Genus *Fenestella:* its History, Development, and Range in Space and Time. I. History of the Genus. By G. R. Vine. (With 4 woodcuts.)

Microscopy.—The Congress of Microscopists (held at Indianapolis).—Microscopical Society of Liverpool (Meeting of 11th October).—A Remarkable Photograph (Lord's Prayer in $\frac{1}{10000}$ of a square inch).

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A few Words about a little Gnat. By Edward Cox. (With a woodcut.)

Fossil Polyzoa (*continued*).

Microscopy.—Varnish for Glycerine Mounts.—New Diatoms.—Diatoms in Coal.—A Collecting Stick.

NATURE:—

October 24:—On a New Method of Studying the Optical Characters of Minerals. (Address by the Chairman, H. C. Sorby, F.R.S., Pres. G.S., &c., at the Meeting of the Yorkshire Geological and Polytechnic Society, held in Selby, on March 13.) November 28:—Biological Notes:—Gall-making Insects.

THE JOURNAL OF THE LINNEAN SOCIETY (BOTANY), Vol. XVII., No. 99 (issued 5th November):—

The Fungi of Texas. By M. C. Cooke, A.L.S.

On the Mechanism for the Fertilisation of *Meyenia erecta*, Benth. By R. Irwin Lynch, of Kew Gardens. (With a woodcut.)

Remarks on Mr. Crombie's Paper on the 'Challenger' Lichens in 'Jour. Linn. Soc.,' vol. xvi. By James Stirton, M.D., F.L.S.

(ZOOLOGY) Vol. XIV., No. 76 (issued 31st October):—

The Life-History of *Filaria Bancrofti*, as explained by the Discoveries of Wucherer, Lewis, Bancroft, Manson, Sonsino, myself, and others. By T. Spencer Cobbold, M.D., F.R.S., F.L.S., Professor of Botany and Helminthology, Royal Veterinary College.

On the action of Limpets (*Patella*) in sinking Pits in and abrading the surface of the Chalk at Dover. By J. Clarke Hawkshaw, M.A., F.G.S.

JOURNAL OF THE QUEKETT MICROSCOPICAL CLUB, No. 38 (October):—

On an Apparatus for facilitating the use of "Powell's Small Bull's-eye" Illuminator in the Resolution of Test Objects. By Geo. Williams. (With a plate.)

On the Influence of Diffraction in Microscopic Vision. By Frank Crisp, LL.B., B.A., Sec. R.M.S., V.P.Q.M.C. (With a plate.)

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Proceedings of the Meetings of 10th and 24th May, 14th and 28th June, 12th and 26th July.

Thirteenth Report of the Club, List of Members, Rules, &c.

AMERICAN JOURNAL OF MICROSCOPY AND POPULAR SCIENCE for October :—

Volvox globator. By A. W. Bennett, M.A., B.Sc., F.L.S. (With a plate.) (From 'Pop. Sc. Rev.')

A few Remarks on Insect Dissection. By T. Charters White, M.R.C.S., F.R.M.S., &c. (From 'Journal of Quekett Microscopical Club.')

Professor Abbe on the Defining and Resolving Powers of the Microscope.

On a Method of Mounting whole Insects without Pressure for the Binocular Microscope. By Staniforth Green. (From 'Journal of the Quekett Microscopical Club.')

The Effect of Politeness. (From 'Nature.')

Oleomargarine. By John Michels. (With 2 woodcuts.)

The Microscope in Medicine. (From King's 'Urological Dictionary.')

The Hard Tissues of Animals—their Origin and Formation. Paper read by Mr. X. Clark before the San Francisco Microscopical Society, 19th September, 1878.

To Remove tight Stoppers. ('From Amateur's Handbook.')—Glass Working. (Ditto.)—Instruction in Microscopy.—New Rooms of the New York Microscopical Society.—Deposits from Water of the Mississippi River.—The proposed Micrometric Unit —*Correspondence.*—Oiling the Microscope. C. S.—*Transactions* of the San Francisco Microscopical Society of 19th September.

For November :—

The Germ Theory of Disease and its present bearing upon public and personal Hygiene. A Lecture by Professor Jos. G. Richardson, M.D. (From the 'Medical Record.')

Hyalodiscus subtilis and H. Californicus. By F. Kitton, Hon. F.R.M.S. With Notes by Professor H. L. Smith. (With 8 woodcuts.)

Notes on Microscopic Life in the Buffalo Water Supply. By D. S. Kellicott.

The Woodward Prism.

The Weber Slide. (With a woodcut.)

Carl Zeiss' New Oil-Immersion Objective of $\frac{1}{12}$-inch Focus. No. 5. By A. Schulze. (From the 'English Mechanic.')

The "Oil-Immersion" of Carl Zeiss compared with the Objectives of C. G. Spencer and Sons. By Professor H. L. Smith, LL.D. ('From Am. Quar. Mic. Jour.')

A Correction (Micrometers).

Our Book Table.—The American Quarterly Microscopical Journal. —The Amateur's Handbook of Practical Information.

Correspondence.—On Objectives: W. G. Lapham.—A query for Mr. Merriman: "Turntable."—Mr. Merriman's Answer.—Oleomargarine: W. H. Brewer, and Note by the Editor.

Current Notes.—Professor P. J. Cleve's Diatoms, &c.

Transactions of Societies.—San Francisco Microscopical Society: 3rd and 17th October.—State Microscopical Society of Illinois: 25th October.—Microscopical Section, Troy Scientific Association: 7th October.

Exchanges.

AMERICAN QUARTERLY MICROSCOPICAL JOURNAL, Vol. I., No. 1 (October):—

The Sting of the Honey Bee. By J. D. Hyatt. (With 2 plates.)

Demodex folliculorum.

Description of New Species of Diatoms. By Professor H. L. Smith, LL.D. (With a plate.)

Observations on several Forms of Saprolegnieæ. By F. B. Hine, B.S. (With 4 plates.)

The "Oil-Immersion" of Carl Zeiss compared with the Objectives of C. A. Spencer and Sons. By Professor H. L. Smith, LL.D.

The Microscopical Examination of Fibers. By W. H. Seaman.

Emigration in Passive Hyperæmia. By W. T. Belfield, M.D.

A new Device for Dark-Field Illumination. By Professor Wm. Lighton. (With a woodcut.)

On the Spore-Formation of the Mesocarpeæ. By E. Perceval Wright. (From 'Nature.')
On the Structure of Blood-corpuscles.
A Standard Micrometer. By R. Hitchcock.

Editorial:—

Salutatory.—Is there a Science of Microscopy?—Dredging in the Gulf of Mexico.—The National Microscopical Congress.—Notes.—Laboratory Notes and Queries.—Digest of Current Literature.—Book Notices.—Publications received.

Transactions of the New York Microscopical Society:—

Introductory.—Micrometry. By Romyn Hitchcock.—Oblique Illumination and means of obtaining it. By R. Hitchcock. (With a woodcut.)—Proceedings—20th September.

AMERICAN NATURALIST for October:—

How Thistles spin. By Professor W. J. Beal. (With 7 woodcuts.)
Microscopy.—National Microscopical Congress.—Microscopical Directory.—Exchanges.

JOURNAL DE MICROGRAPHIE for November:—

Micrography at the Exhibition of 1878. By Dr. J. Pelletan.
Universal Exhibition of Paris. List of the Rewards. Class 15, Instruments of Precision.
The Lymphatic Hearts (*continuation*). By Professor L. Ranvier.
Angular Aperture of Microscopic Objectives. By Dr. G. E. Blackham, President of the Microscopical Society of Dunkirk, U.S. (With a plate.)
On Foreign Microscopes (*continuation*). By Dr. J. Pelletan. (With 2 woodcuts.)
Objectives with new Cover Adjustment (*à liquide interposé*).
The New $\frac{1}{8}$ 'Oil of Cedar' Immersion Objective of Carl Zeiss. (From the 'Bulletin of the Belgian Society of Microscopy.')
The Cabinet of Microscopy of Mr. E. Wheeler.

ANNALES DES SCIENCES NATURELLES (ZOOLOGIE), Sixth Series, Vol. VII., Nos. 2–4 (issued in August):—

Description of rare or new Crustacea of the French Coast. By M. Hesse. (With a plate.)
Experiments on the Conditions of Development of the *Ligulæ*. (Abstracted from 'Comptes Rendus.') By M. Duchamp.

(BOTANIQUE.) Sixth Series. Vol. VI., Nos. 5 & 6 (issued in October):—

Development of the Embryo-sac of the Angiospermous Phanerogams. By M. Julien Vesque. (With 6 plates.)

COMPTES RENDUS Hebdomadaires des Séances de l'Académie des Sciences, Vol. LXXXVI., No. 1 (7th January):—

Researches on the Intracellular Alcoholic Fermentation of Plants. By M. A. Muntz.
On the Inversion and on the Alcoholic Fermentation of Cane Sugar by Mouldiness. By M. U. Gayon.
Some Remarks on the Origin of the Alcoholic Yeasts. By M. A. Trécul.
Verbal Reply of M. Pasteur to M. Trécul.
On the Formation of the Fibrin of Blood, studied with the Microscope. By M. G. Hayem.

No. 2 (14th January):—

Note on M. Trécul's Communication in the last Number. By M. Pasteur.

No. 4 (28th January):—

Report of the Commission on the Bordin Prize—M. Charles Eugene Bertrand's Essays: (1) Can the Group of the Lycopodiaceæ be regarded as a transition Group between the Dicotyledonous Gymnospermous Phanerogams and the Vascular Cryptogams? and (2) Comparative Anatomy of the Integuments of Seed.

Report of the Commission on the Thore Prize—M. Jousset de Bellesme's Essay on the Phenomena of Digestion in Insects.

No. 5 (4th February):—

On the Employment of the Polarizing Microscope with Parallel Light for the Determination of the Species of Minerals contained in thin Plates of eruptive Rocks. By M. A. Michel-Lévy.

New Researches on the Function of Moulds, and their property of inverting Cane Sugar, with reference to a Note of M. U. Gayon. By M. A. Béchamp.

No. 7 (18th February):—

Refutation of the Criticisms that M. Pasteur has made on my opinion as to the Origin of Alcoholic Yeasts and Lactic Yeast. By M. A. Trécul.

On the Conditions of Development of the *Ligulæ.* By M. G. Duchamp.

No. 8 (25th February):—

The Action of Oxygen on the Anatomical Elements. By M. P. Bert.

The Lactic Fermentation of Sugar of Milk. By M. Ch. Richet.

Classification of the Cestoïdes. By M. Edm. Perrier.

No. 9 (4th March):—

On Lactic Fermentation. By M. L. Boutroux.

Researches on the Chemical Composition and the Functions of the Leaves of Plants. By M. B. Corenwinder.

No. 10 (11th March):—

The Influence of the Discoveries of M. Pasteur on the Progress of Surgery. By M. C. Sédillot.

Remarks relative to the preceding Communication. By M. d'Abbadie.

The precise Orientation of the principal Section of the Nicols in Polarizing Apparatus. By M. L. Laurent.

Classification of Stellerides. By M. C. Viguier.

No. 11 (18th March):—

The Influence of Rest and of Movement in the Phenomena of Life. By M. A. Horvath.

Researches on the Suspension of the Phenomena of Life in the Embryo of the Hen. By M. C. Dareste.

Proofs of the Parasitic Nature of Anthrax. Identity of Lesions in the Rabbit, the Guinea Pig, and the Sheep. By M. H. Toussaint.

No. 12 (25th March):—

On a Camera Lucida. By M. Pellerin.

The Formation of Partitions in the Stylospores of the *Hendersoniæ* and *Pestalozziæ.* By M. L. Crié.

No. 13 (1st April):—

The Conidia of *Polyporus sulfureus*, Bull, and their Development. By M. J. de Seynes.

Anthrax in the Horse and the Dog. Phlogogenic Action of Anthracic Blood. By M. H. Toussaint.

The Epoch of Formation of the Cloaca in the Embryo of the Chicken. By M. Cadiat.

No. 15 (15th April):—

On a Rare Form of the Hepatic Organ in Worms. By M. Joannes Chatin.

Theory of the Action of Bacteria in Anthrax. By M. Toussaint.

No. 17 (29th April):—

The Theory of Germs, and its Applications to Medicine and Surgery. By MM. Pasteur, Joubert, and Chamberland.

No. 18 (6th May):—

On the Gold Method and the Termination of the Nerves in the Unstriated Muscles. By M. L. Ranvier.

On the *Wartelia*, a new Genus of Annelids, wrongly considered the Embryo of *Terebella*. By M. A. Giard.

No. 20 (20th May):—

On the Distinction between the Luminous and Chromatic Sensations. By M. Aug. Charpentier.

On the Terminations of the Nerves in the Sudoriparous Glands of the Paw of the Cat. By M. P. Coyne.

No. 21 (27th May):—

On the Origin of the Excito-sudoral Nerve-fibres contained in the Sciatic Nerve of the Cat. By M. Vulpian.

On the Production of the Luminous Sensation. By M. Aug. Charpentier.

No. 22 (3rd June):—

On the Structure of the Nerves in Invertebrates. By M. Cadiat.

No. 23 (10th June):—

On the Origin of the Excito-sudoral Nerve-fibres of the anterior Limbs of the Cat. By M. A. Vulpian.

Experiment demonstrating that the Nerve-fibres whose excitation causes the dilatation of the Pupil do not all proceed from the Cervical Cord of the great Sympathetic. By M. A. Vulpian.

Anatomical Observations on certain Cutaneous Excretory Glands in the Fluviatile Tortoises of China. By M. Rathouis.

Experimental Proofs of the incomplete crossing of the Nerve-fibres in the Chiasma of the Optic Nerves—Longitudinal and Median Section of the Chiasma not followed by Blindness. By M. Nicati.

No. 24 (17th June):—

On the Gemmiparous and Fissiparous Reproduction of Noctilucæ (*Noctiluca miliaris*, Suriray).

The Functions of the Leaves in the Phenomenon of Gaseous Exchanges between Plants and the Atmosphere—The Rôle of the Stomata in the Functions of the Leaves. By M. Mercet.

No. 25 (24th June):—

Organisms held in suspension in the Atmosphere. By M. P. Miguel.

On some Terricolous Rhizopods. By M. A. Schneider.

Vol. LXXXVII., No. 1 (1st July):—

On Anaërobiosis of Micro-Organisms. By M. Gunning.

No. 2 (8th July):—

On a Disease of an Anthracic Form, caused by a new Aerobic Vibrion. By M. H. Toussaint.

On the Propagation and Metamorphoses of the Suctorial Crustacea of the Family *Cymothoadæ*. By M. Schiödte.

Observations and Experiments on the Migrations of *Filaria rhytipleurites*, a Parasite of Cockroaches and Rats. By M. Osman Galet.

On the Development of the Cephalo-thoracic portion of the Embryo of Vertebrates. By M. Cadiat.

No. 3 (15th July):—

On the Spermatozoïds of the Cestoidea. By M. R. Moniez.

The Septicity of Putrefied Blood is lost by a very long contact with Oxygen compressed at high tension. By M. V. Feltz.

The Structure of the Stem of Sigillaria. By M. Renault.

No. 4 (22nd July):—

On the Theory of Fermentation. By M. Pasteur.

Reply to the Communication of M. Pasteur. By M. Berthelot.

Disease of Black Spots of the Maple (*Rhytisma acerinum*). By M. Max Cornu.

On the Structure of the Sieve-like Tubes. By M. Ed. de Janczewski.

No. 5 (29th July):—

New Communication on the subject of the Notes on Alcoholic Fermentation, found among the Papers of Cl. Bernard. By M. L. Pasteur.

Observations of M. Berthelot consequent on the Communication of M. Pasteur.

No. 6 (5th August):—

No Mycelium intervenes in the Formation and in the Normal Destruction of the Swellings developed under the Influence of the Phylloxera. By M. Max Cornu.

On *Prosopistoma punctifrons*, Latr. By MM. E. Joly and A. Vayzzière.

No. 7 (12th August):—

On the Functions of Leaves. Function of the Stomata in the Exhalation and Inhalation of Aqueous Vapours by Leaves. By M. Merget.

On Parasitic Isopods of the Genus *Entoniscus*. By M. Alf. Giard.

Importance of the Vegetable Cell-walls in the Phenomena of Nutrition. By M. Max Cornu.

No. 8 (19th August):—

Experimental Researches on the Nervous Sudoral Fibres of the Cat. By M. A. Vulpian.

Researches on the Nutrition of Insects. By M. L. Joulin.

No. 9 (26th August):—

Comparison between the Salivary and Sudoriparous Glands, relatively to the way in which they are affected by Section of their Excito-secretory Nerves. By M. Vulpian.

No. 10 (2nd September):—

The Causes of the Buzzing of Insects. By M. J. Perez.

The Application of Borax to Researches in Vegetable Physiology. By M. Schnetzler.

No. 11 (9th September):—

The Oviposition of the Queen-Bee, and the Theory of Dzierzon. By M. J. Perez.

The Reproduction of the *Hydra*. By M. Korotneff.

No. 12 (16th September):—

New Researches on the Physiology of the Vesicular Epithelium. By MM. P. Cazeneuve and Ch. Livon.

No. 13 (23rd September) :—

On the Development of Chilostoman Bryozoa. By M. J. Barrois.

No. 15 (7th October) :—

Note on a Memoir addressed to the Academy by M. J. Perez on the Buzzing of Insects. By M. Jousset de Bellesme.

On *Trichodonopsis paradoxa* (Clap.). By M. A. Schneider.

No. 16 (14th October) :—

On a new Micrometer, intended especially for Meteorological Researches. By M. G. Govi.

BULLETIN DE LA SOCIÉTÉ BELGE DE MICROSCOPIE, Vol. IV., No. 12 :—

Proceedings of the Meeting of 26th September, 1878.

The Malignant Tumours of the First and Second Childhood. By Dr. Ledeganck. (With 2 plates.)

Analytical and Critical Review—of M. A. Renard's paper on "the Diabase of Challes near Stavelot,' in No. 8 of the 'Bulletin de l'Académie Royale des Sciences, Lettres et Beaux-Arts de Belgique,' and of No. 8 of the 'Zeitschrift für Mikroskopie.'

Proceedings of the Annual General Meeting of 13th October, 1878, including the Report of the Council.

General List of the Members of the Society.

Academies, Societies, and Institutions with which the Society exchanges publications.

Vol. V., No. 1.

Proceedings of the Meeting of 31st October, 1878.

Report by M. Delogne on Dr. Matteo Lanzi's book 'The Thallus of the Diatomaceæ.'

Analytical and Critical Review of M. Thoulet's paper on a "Process for measuring the solid angles of Microscopic Crystals," in the 'Bulletin de la Société Mineralogique de France,' 1878, No. 4, and of No. 9 of the 'Zeitschrift für Mikroskopie.'

ZEITSCHRIFT FÜR MIKROSKOPIE, Vol. I., Part 9 (October) :—

The Development and Present Position of Microscopy in Germany (*conclusion*). By Dr. Kaiser.

On the Preparation and Preservation of Microscopic Aquatic Animals.

Foreign Microscopes (*continuation*). By Dr. J. Pelletan. (From 'Journal de Micrographie.')

A new Measurer for Covering-glass.

On Washing and Cleaning Diatom-material. By C. Janisch.

Minor Communications.—Preservation of Planaria. (From 'Zool. Anzeiger.')

Literature.

ZEITSCHRIFT FÜR WISSENSCHAFTLICHE ZOOLOGIE, Vol. XXXI., Parts 3 and 4 (issued 11th November) :—

Contributions to the Anatomy of the Ophiuræ. By H. Ludwig. (With 4 plates and a woodcut.)

On the Genital Organs of *Asterina gibbosa*. By H. Ludwig. (With a plate.)

Contributions to the Anatomy of Magelona. By W. C. McIntosh. (With 10 plates.)

On some Cases of Parasitism in Infusoria. By I. van Rees. (With a plate.)

The Development History of the Pond and River Mussel. By C. Schierholz.

PROCEEDINGS OF THE SOCIETY.

MEETING OF 13TH NOVEMBER, 1878, AT KING'S COLLEGE, STRAND, W.C.
THE PRESIDENT (H. J. SLACK, ESQ.) IN THE CHAIR.

The Minutes of the meeting of 9th October were read and confirmed, and were signed by the President.

The following List of the Donations since the last meeting was submitted, and the thanks of the Society given to the donors.

	From
Annales des Sciences Naturelles (Zoologie). 14 vols. (1870 to 1877)	*Mr. Frank Crisp.*
,, ,, ,, (Botanique). 13 vols. (1869 to 1877).	*Ditto.*
Henry, James.—Æneidea; or Critical, Exegetical, and Æsthetical Remarks on the Æneis. 4 parts. 1873–8	*Author.*
Papers of the Eastbourne Natural History Society, 1877 and 1878	*Society.*
Wallich, Surgeon-Major G. C.—On the Radiolaria as an Order of the Protozoa. (From 'Popular Science Review')	*Author.*
Zeitschrift für wissenschaftliche Zoologie. 10 vols. (1869 to 1877).	*Mr. Frank Crisp.*

A special vote of thanks was on the suggestion of the President given to Mr. Crisp for his valuable donations.

Dr. G. W. Royston-Pigott, M.A., F.R.S., explained the leading points of a paper which he had sent to the Society, "On a further Inquiry into the Limits of Microscopic Vision, and the delusive Application of Fraunhofer's Optical Law of Vision." The subject was illustrated by numerous diagrams. (The paper will be printed in the next number of the Journal.)

The President read a paper by himself, "On the Visibility and Optical Aspects of Hairs viewed from a Distance." (The paper will be found at p. 318.)

Mr. Charles Brooke, in reply to a question from the President, said that he thought the hair itself was not actually seen. On the occasion when being illuminated by the sun-light a bright line was perceived at the great distance of 173 feet, he considered that the perception of it was due to an optical effect similar to that produced by the heating of a platinum wire by a current of electricity, when the wire apparently increased in thickness the hotter and brighter it became.

Mr. Henry Davis said that the phenomenon was well known to astronomical observers under the name of irradiation, and it applied generally to all bright objects.

Mr. Stewart inquired whether in the course of these experiments there was anything like "expectant attention" on the part of the persons concerned in them? Did they not know what they were to look for and exactly how they ought to see it, or were the hairs placed in positions vertically or otherwise without the persons knowing which way they were placed, so as to test whether they really did see them?

The President said there was no attempt made to try the extreme distance at which the hairs could be seen, all the persons were required to do was to state a distance at which they could be distinctly seen. In one case the person did not know the position of the hairs; it was one of his men who had just come up from the village and did not know what they were about. In another case a person saw the horizontal hair, but failed to see the vertical one; and there was no endeavour made to ascertain who could see the objects at the greatest distance. One suggestion bearing upon the subject he thought might be a point for consideration, and that was that seeing the image of an object of 1 millionth of an inch in diameter might not be the same as seeing an object of that diameter. He had hoped to have seen Professor Stokes this evening, but he was engaged at Cambridge.

Mr. Crisp said that as Professor Stokes had been referred to, it might not be without interest to read an extract from a letter referring to the subject, addressed by that gentleman to Mr. Mayall some time since:—

"As to Fraunhofer's formula, it is that which applies to the diffraction spectra formed by fine equidistant lines, and to that alone. The whole of the circumstances are so different from those of the illumination and viewing of microscopic objects, that we have no right, I think, to draw any conclusion against the visibility of very fine objects, even though they be Nobert's lines, and therefore of the same nature as the object to which Fraunhofer's formula refers. In the Fraunhofer spectra the object is illuminated by nearly parallel rays, and the instrument is focussed *for the distant slit*, and the angular aperture is some 3° or 4° or less. When Nobert's lines are used as a test, the object is illuminated by strongly condensed light, the instrument is focussed *for the lines themselves*, and the angular aperture of the microscope objective is very much greater."

He also read the following note from Mr. Mayall, which accompanied it:—

"In Arago's 'Astronomy' there are some curious remarks made on Photometry, which I think bear strongly on the question of the limit of visibility. Briefly this is the result at which Arago arrived:—If two adjacent points on a surface be unequally illuminated, the eye is capable of perceiving the difference when it is greater than $\frac{1}{60}$; a less difference than $\frac{1}{60}$ (or thereabouts) cannot be seen by the eye, and the two points will appear equally illuminated, and therefore not discernible as separated.

"Applying this experiment to the microscope: suppose we have an anatomical preparation, unequally transparent, so that the most transparent part allows 61 rays to pass through, whereas the adjacent part allows only 60 rays to pass through; the eye still perceives the difference between them. But this is the limit (or thereabouts), otherwise the eye sees only a uniform surface.

"This difference of $\frac{1}{60}$ that follows from Arago's experiments as the limit of perception by the eye, is not an absolute quantity, but will depend somewhat on the sensitiveness in individual eyes.

"Again, too, it will depend on the intensity of the light in which the observation is made. There is necessarily a particular intensity the most favourable to enable us to distinguish these small differences.

"If we look at the sun with the naked eye, we do not see the spots, although from their size they should be seen. If we take a smoked glass we see them at once. With too dark a glass they disappear, although we may still see the disk of the sun. This phenomenon takes place with the microscope when the illumination is too brilliant or not sufficiently so."

The President said that Dr. Pigott, after the meeting, would exhibit his apparatus to the Fellows.

Mr. F. H. Wenham read a paper "On the Measurement of the Angle of Aperture of Objectives," illustrating the subject by a diagram, enlarged upon the black-board by Mr. Stewart. Mr. Wenham also said that Mr. H. Davis, who was present, had seen the operation of measurement, and would vouch for the fact that it was a very simple affair. (Mr. Wenham's paper will be found at p. 321.)

Mr. Henry Davis gave some extracts from a paper he was about to present "On the Pygidium of Insects," illustrating his observations by drawings on the black-board. (The paper will be printed in the next number of the Journal.)

Mr. Charles Stewart thought that the term pygidium was merely the name given to a particular tergal plate of the posterior part of the abdomen, upon which, in the case of the flea, these curious hairs were found. He believed that somewhat similar hairs had been described by Dr. Braxted Hicks and others, as occurring on other parts of the bodies of insects. He only wished to ask, as a matter of information, whether the term was applied to the hairs, or whether it belonged to the particular part upon which they were ordinarily found? The *circi*, as these things had been called to which Mr. Davis drew attention, were really a pair of upstanding bodies, and were each divided into twelve little pieces; they were not at all unlike posterior antennæ, and he thought they would hardly come within the description of pygidia, although they might bear similar hairs, and perform a like function.

Mr. Davis said that the term had always been applied to the organ itself in the case of the lace-wing fly, and therefore he had from its analogy applied it to the organs of other insects; but if it was wrong to apply it to the fly, then it was wrong to apply it to the others. On the other hand, however, if this organ in the lace-wing fly was a pygidium, then that of the locust was certainly a pygidium also. In some of the species of cockroach, the same thing was found starting from the same place, but only carried out a little longer. As regarded the cockroach (*Blatta*), it might at first be thought that the thing was not the same, but he felt sure that if anyone went through them carefully and traced them out by their analogies, there would be no difficulty in showing that they were really the same.

Mr. Stewart said that if he recollected rightly, at the posterior end of the flea there was a somewhat kidney-shaped plate (drawn on the blackboard) containing certain wheel-shaped markings, with a hair starting from each. The question was whether any part bearing similar hairs should also be called a pygidium, or whether it should only be given to an homologous part.

Mr. Davis did not think that he was bound to prove the identity of the thing as being a pygidium; it was for others to do that. What he had endeavoured to do was to show that in all these insects there were similar organs, and that they served similar purposes.

Mr. Beck did not quite understand the question in dispute; it seemed to him to be whether the term was rightly applied to the object or not, or whether it only applied to that portion of the "shell" which in the flea had a certain structure upon it. They all knew that certain portions of an insect had certain names given to them, and Mr. Stewart stated that there was a certain portion of the flea called the pygidium which happened to have upon it the very beautiful object which was ordinarily called by the same name by microscopists. The question was, were they right in calling this beautiful portion the pygidium? If this was so, and it was a special organ, there might be a similar organ found in other insects. Mr. Davis had been endeavouring to trace a similar organ in others, and having found it there, he called it also a pygidium, whereas Mr. Stewart said the term applied to a position only. He thought the two things might very well be brought into harmony without much difficulty.

The President said that the term pygidium would really apply to the position of the part rather than to its special form or function. From its derivation the word would merely indicate something near the tail of the creature.

Mr. Stewart said he had no doubt as to what was the pygidium of the flea; what he had wanted to know was what Mr. Davis thought of the homology of the body which he had described.

The President said that there might be two things which were morphologically different, but which performed the same functions.

Mr. Crisp said that it would be remembered that they had recently had a paper by Mr. F. A. Bedwell, on the mastax of *Melicerta ringens;* since that paper appeared he had lent Mr. Bedwell the Zeiss oil-immersion ($\frac{1}{8}$), and he read extracts from a letter from Mr. Bedwell after having used the glass:—"It is the most magical addition to the instrument, and I feel certain that it will revolutionize a vast mass of information; many papers will have to be rewritten, amongst others my last on the mastax of *Melicerta ringens.* Wherever organic *texture* is concerned, this glass makes the invisible visible. As an example, I send you two slides of mastax of *M. ringens,* and one of *Rotifer vulgaris,* by Lord Sydney G. Osborne. If you look at them with an ordinary $\frac{1}{8}$, and then with the immersion, you will see that a part of the *ramus* in *Melicerta* which I have drawn in my picture as a plane surface, is exquisitely furrowed, and comes out like a revelation; while the teeth and notches in *Rotifer vulgaris* appear *at once*, and you may work for an hour with an ordinary $\frac{1}{8}$ and never separate them. The slides will serve as well as anything to show the value of the glass."

He also read extracts from a letter received from Dr. Fripp, of Bristol, in regard to Mr. Dallinger's paper on the measurement of the diameter of the flagella of *Bacterium termo*. (The letter will be found on p. 337.)

Mr. Stewart exhibited and described with drawings on the blackboard a slide of *Onchopora hirsuta* which Mr. Weightman, of Liverpool, had sent to the Society.

Mr. Crisp exhibited (1) Zentmayer's "Centennial" microscope, which had obtained a medal at the Paris Exhibition. The stand is provided with three different stages; a mechanical one with the usual movements, a large circular one with concentric rotatory motion, and a small concentric rotating "diatom-stage" bevelled out on its under surface, so as to allow of extremely oblique illumination, or, if still greater obliquity is desired, the stage can be reversed and the slide attached beneath, so that the utmost freedom is obtained for oblique illumination. The sub-stage bar, carrying the mirror and condenser, is made to swing on a pinion adjusted so that the object itself forms the centre of rotation; thus the sub-stage appliances can be used at any degree of obliquity beneath the object, or they may be swung above the stage for illuminating opaque objects. (2) Photograph of the Tolles-Blackham microscope (lent by Mr. Mayall), showing the circular disk that had been devised to obtain a swinging motion to the sub-stage without infringing Mr. Zentmayer's patent. (3) Photograph by Col. Woodward of *Amphipleura pellucida* in balsam, by Tolles' $\frac{1}{10}$ immersion (glycerine) objective.

The following gentlemen were elected Fellows of the Society:—Captain Peter G. Cunliffe; M. Julien Deby, Vice-President of the Belgian Society of Microscopy; Mr. John Morris, F.S.S., F.Z.S.

Scientific Evening.

The first Scientific Evening of the Session was held in the Libraries of King's College on the evening of Wednesday, the 27th November, 1878.

The following were the objects exhibited:—

Mr. Beck:

- Artificial siliceous deposit with markings resembling those on *Pleurosigma angulatum*.
- A new crystal—quinate of quinine—polarized.
- Mr. Gorham's complementary colour disks.

Mr. C. Baker:

Double-stained vegetable tissues.

Zeiss's oil-immersion $\frac{1}{12}$.

Micro-photograph, referred to at p. 300.

Mr. Thos. Bolton:

Ophrydium longipes, *Cephalosiphon*, *Stephanosceros*, and other Rotifers.

Raphidiophrys pallida—a Rhizopod new to this country.

Of this genus, Professor E. Ray Lankester writes:—"It was founded by Mr. Archer, of Dublin, who described a fine green specimen in the 'Q. J. Mic. Sc.,' 1869 (plate xvi.). It is characterized by having a single excentric nucleus, surrounded by dense protoplasm in which are three or four contractile vacuoles; outside this is a gelatinous investment, and in this are imbedded slightly curved siliceous spicules in masses. Delicate filamentous pseudopodia radiate through the gelatinous coat, and as in Actinosphærium *send fibrous continuations* to a central point in the protoplasm.

This species is colourless, Archer's species is green. I have seen all these points of structure to-day by treating the specimen on the slide of the microscope under cover-glass, first with osmic acid, then with picro-carmine, and then alternately with glycerine and water. The glycerine prevents the spicules being seen, being of the same refractive index, but renders the protoplasm clearer. The nucleus is only seen well after staining. The form is highly interesting, and one I was very glad to see."

Mr. Frank Crisp:

Zentmayer's double-stained and other preparations from the Paris Exhibition, with Zentmayer's "Centennial" stand and diatom stage.

Professor S. P. Thompson's Strobic Circles.

Mr. Thos. Curties:

Sections of stipes of ferns by M. Kruitcheruit, of New Orleans.

Mr. W. G. Cocks:

A singular caterpillar found on the Eucalyptus in Adelaide.

Mr. H. Crouch:

New $\frac{1}{2}$-in. objective for dissecting microscope.

New microscope for students' use.

Spencer and Sons (New York) $\frac{1}{10}$ and $\frac{1}{6}$ dry and immersion objectives, $\frac{1}{4}$-in. dry ditto, for which the gold medal was awarded at the late Paris Exhibition.

Mr. Bolton's new microscope revolving tables (2).

Mr. Enock:

Various tongues of Hymenoptera, prepared without pressure.

Dr. Edmunds:

The four-faced immersion prism (with faces inclined at 60°, 49°, 41°, and 30°), referred to at p. 309.

Mr. F. Fitch:
Balanus balanoides.
Chyle, stomach, and appendages of drone-fly.
Teeth of blow-fly shown in relief.

Mr. C. J. Fox:
Polariscope for convergent light, with mica and selenite combinations.

Rev. T. W. Freckelton:
Macrospores and microspores from coal, compared with spores of *Selaginella selaginoides.*

Mr. H. E. Freeman:
Eggs of *Gasterophilus equi* from body of female, showing provision for attachment to hairs of the horse.

Dr. W. J. Gray:
Rutilaria epsilon and other rare diatoms.

Messrs. J. How and Company:
Fossil wood with insect borings and excreta, &c.
A new microscope lamp.

Mr. J. Mayall, jun.:
Some special slides of *Amphipleura pellucida.*

Dr. Millar:
A new camera lucida, designed by Dr. Russell, of Lancaster.

Dr. Matthews:
Triceratium favus, arranged to show images of a black cross.
Stylaster sanguineus.

Mr. A. D. Michael:
The newly discovered male of *Cheyletus venustissimus* (see p. 313).

Professor Owen, C.B.:
Sections of "Granicones," described at p. 233.

Mr. F. Oxley:
The so-called "Pygidia" of grasshoppers, crickets, &c.

Mr. Thos. Palmer:
Sections of butcher's broom, common cane, &c.

Mr. B. A. Priest:
Portion of the bag of a starfish from China.

Mr. W. W. Reeves:
Section through the cone (*Lepidostrobus*) of *Lepidodendron*, with spores *in situ*, from Lancashire coal-measures.

Mr. C. Stewart:
Section through the growing point of *Anacharis alsinastrum.*

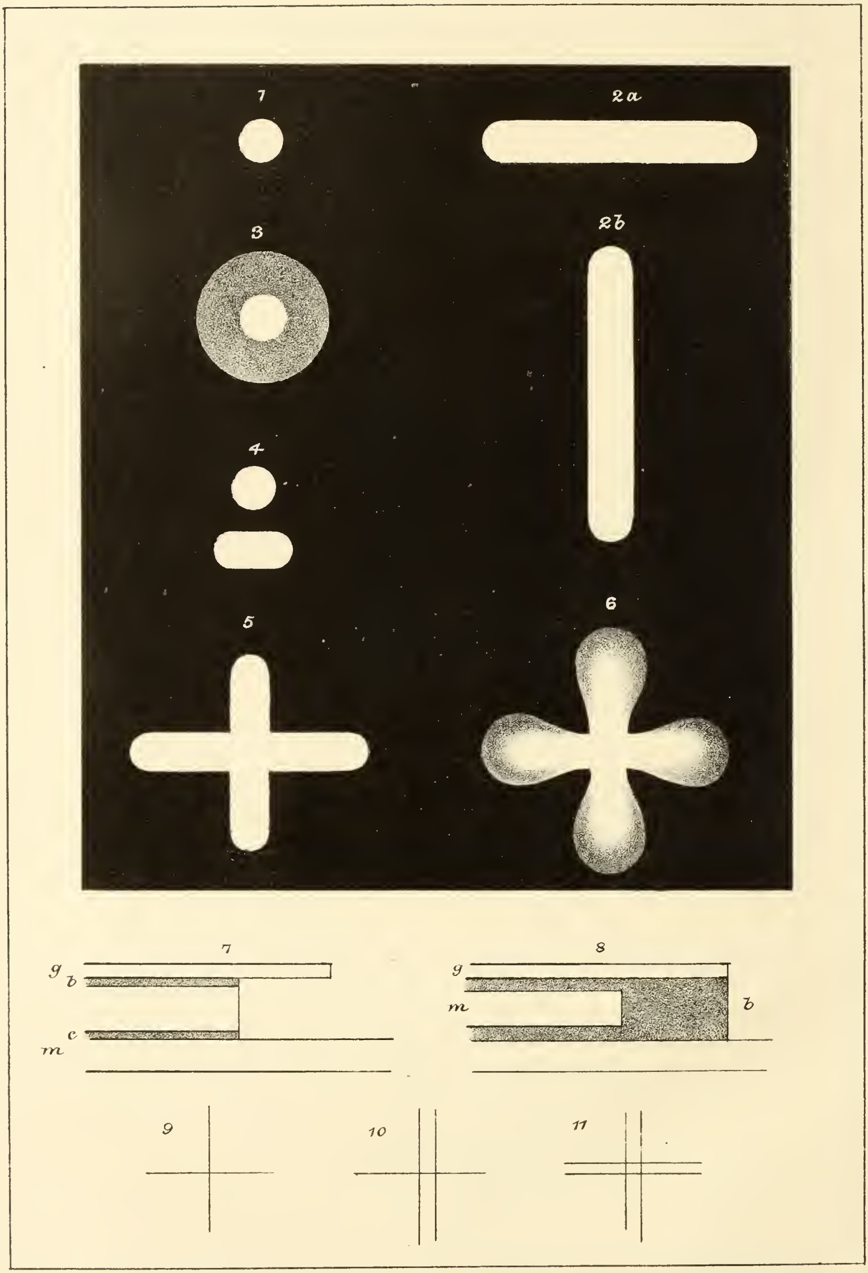
Mr. A. Topping:
Various sections from the tail of a whale (stained).

Mr. F. H. Ward:
Sections (24) of various plants double stained by himself.

INDEX TO VOLUME I.

END OF VOLUME I.

LONDON: PRINTED BY WILLIAM CLOWES AND SONS, STAMFORD STREET AND CHARING CROSS.



W. West & Co. lith.

Some optical characters of Crystals.

Fig. 1.

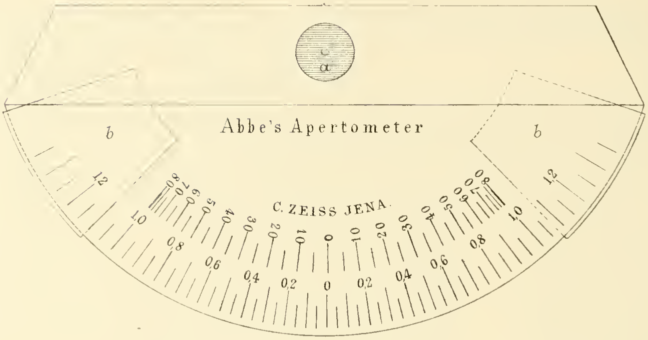


Fig. 2.

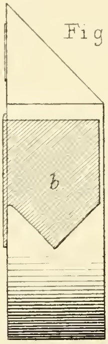


Fig. 3.

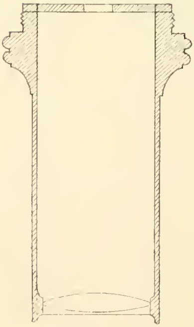
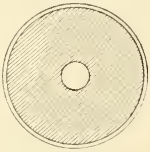


Fig. 4.



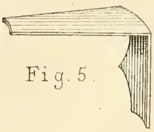
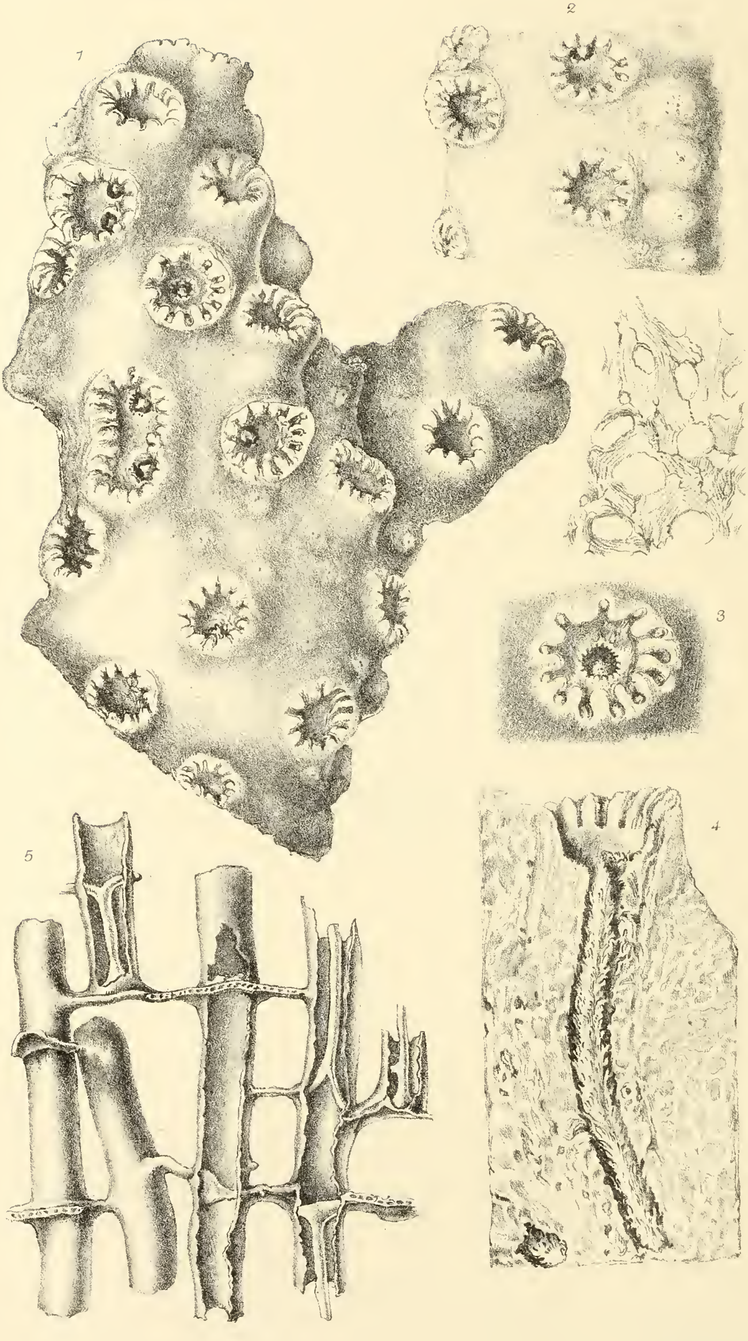


Fig. 5.

Abbe's Apertometer.



C. Stewart del.

W. West & Co lith.

Stylaster stellulatus & Tubipora musica.

Trans R. M. S. Vol 1. Plate 4.

Dr Schmidt del.
W West & Co lith.

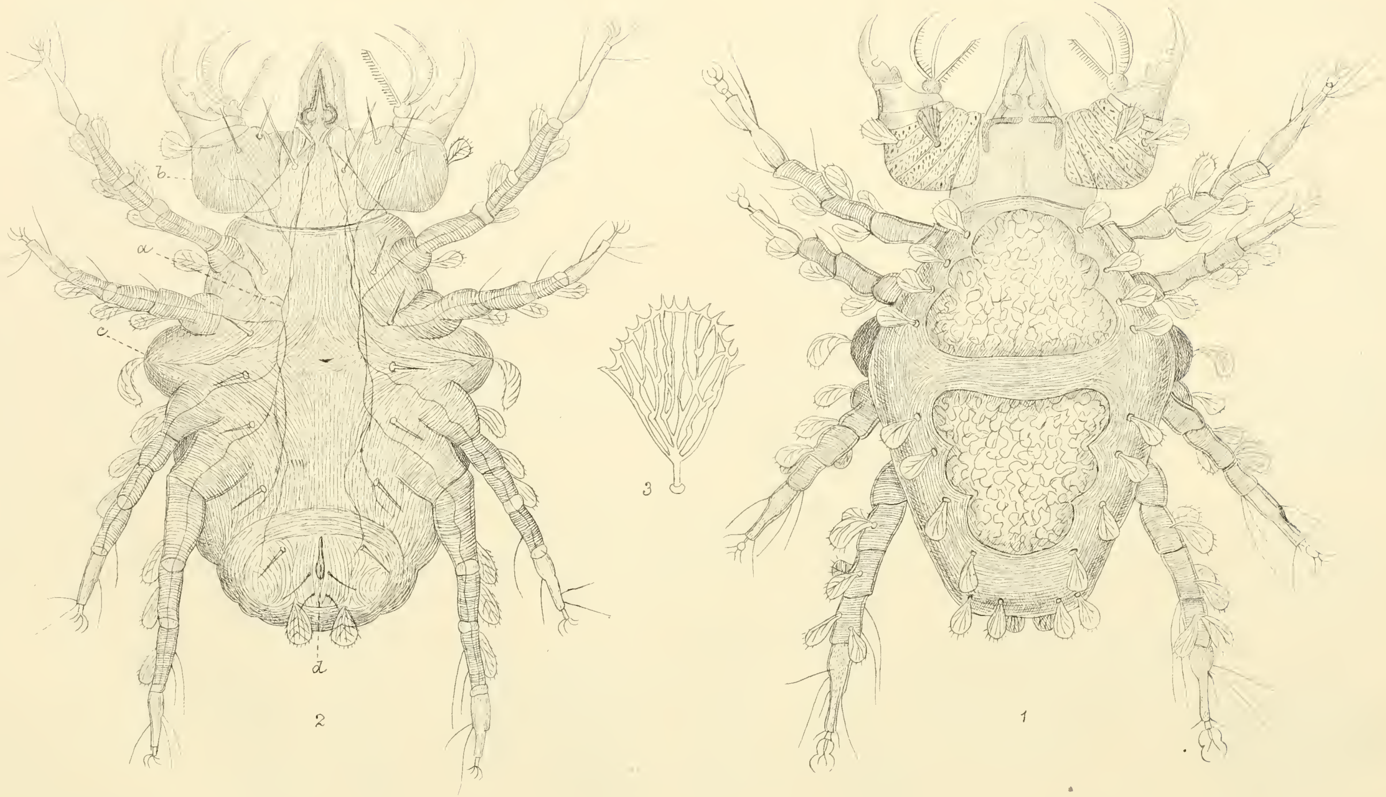
Blood-corpuscles of Amphiuma tridactylum.

Tra: s. R.M.S. Vol. 1. Plate 5.

Dr. Schmidt del.

W West & Co. lith.

Blood corpuscles of Amphiuma Frog and Man.



A.Michael del. W.West & Co. sc.

Cheyletus Flabellifer.

Elements and Computation of the one sixth immersion objective made by M^r R. B. Tolles, and owned by M^r Crisp.

Formula and Elements.

$\sin\epsilon_1 = \frac{1}{10}h_1$
$\sin\theta_1 = \frac{1}{r}h_1$
$\sin(\epsilon_2-\theta_1) = \frac{1}{\mu_1}\sin(\epsilon_1-\theta_1)$
$D_2 = r_1\sin(\epsilon_2-\theta_1)\operatorname{Cosec}\epsilon_2$
$S_2 = r_1 - r_2 + t_1$
$\sin(\epsilon_2-\theta_2) = r_2\sin\epsilon_2(D_2-S_2)$
$\sin(\epsilon_3-\theta_2) = \frac{1}{\mu_2}\sin(\epsilon_2-\theta_2)$
$D_3 = r_2\sin(\epsilon_3-\theta_2)\operatorname{Cosec}\epsilon_3$
$S_3 = r_2 + t_2$
$\sin\epsilon_4 = \frac{1}{\mu_3}\sin\epsilon_3$
$D_4 = \tan\epsilon_3\cot\epsilon_4(D_3-S_3)$
$S_4 = r_4 - t_3$
$\sin(\epsilon_4-\theta_4) = \frac{1}{r_4}\sin\epsilon_4(D_4-S_4)$
$\sin(\epsilon_5-\theta_4) = \frac{1}{\mu_4}\sin(\epsilon_4-\theta_4)$
$D_5 = r_4\sin(\epsilon_5-\theta_4)\operatorname{Cosec}\epsilon_5$
$S_5 = r_4 - r_5 + t_4$
$\sin(\epsilon_5-\theta_5) = \frac{1}{r_5}\sin\epsilon_5(D_5-S_5)$
$\sin(\epsilon_6-\theta_5) = \frac{1}{\mu_5}\sin(\epsilon_5-\theta_5)$
$D_6 = r_5\sin(\epsilon_6-\theta_5)\operatorname{Cosec}\epsilon_6$

$S_6 = r_5 - r_6 + t_5$
$\sin(\epsilon_6-\theta_6) = \frac{1}{r_6}\sin\epsilon_6(D_6-S_6)$
$\sin(\epsilon_7-\theta_6) = \frac{1}{\mu_6}\sin(\epsilon_6-\theta_6)$
$D_7 = r_6\sin(\epsilon_7-\theta_6)\operatorname{Cosec}\epsilon_7$
$S_7 = r_6 + t_6$
$\sin\epsilon_8 = \frac{1}{\mu_7}\sin\epsilon_7$
$D_8 = \tan\epsilon_7\cot\epsilon_8(D_7-S_7)$
$S_8 = r_8 - t_7$
$\sin(\epsilon_8-\theta_8) = \frac{1}{r_8}\sin\epsilon_8(D_8+S_8)$
$\sin(\epsilon_9-\theta_8) = \frac{1}{\mu_8}\sin(\epsilon_8-\theta_8)$
$D_9 = r_8\sin(\epsilon_9-\theta_8)\operatorname{Cosec}\epsilon_9$
$S_9 = r_8 + t_8$
$\sin\epsilon_{10} = \frac{1}{\mu_9}\sin\epsilon_8$
$D_{10} = \tan\epsilon_9\cot\epsilon_{10}(D_9-S_9)$
$S_{10} = r_{10} - t_9$
$\sin(\epsilon_{10}-\theta_{10}) = \frac{1}{r_{10}}\sin\epsilon_{10}(D_{10}+S_{10})$
$\sin(\epsilon_{11}-\theta_{10}) = \frac{1}{\mu_{10}}\sin(\epsilon_{10}-\theta_{10})$
$D_{11} = r_{10}\sin(\epsilon_{11}-\theta_{10})\operatorname{Cosec}\epsilon_{11}$
$S_{11} = r_{10} + t_{10}$

In which

h_1 = Semidiameter of the back lens
r = Radius of Curvature
ϵ = Angle made by the outside ray with the axis.
θ = Angle made by the radius with the axis
μ = Refractive index of the following medium divided by that of the preceding
t = The distance along the axis from one surface to the next.
u_1 = Distance from the radiant along the axis to the first surface.

r, ϵ, θ, and u, positive when between the surface and the radiant

The surfaces and letters are numbered in order from the back towards the front

The distance of the radiant behind the back is such that $10\sin\epsilon_1 = h_1$

The elements furnished by M^r Tolles are

r_1	-0 52	t_1	0.132	$l\ \mu_1$	0.18327
r_2	0.40	t_2	0 02	$l\ \mu_2$	0.03684
r_3	0.∞	t_3	0 045	$l\ \mu_3$	9 96316
r_4	1 80	t_4	0.010	$l\ \mu_4$	9 81673
r_5	-0 35	t_5	0.145	$l\ \mu_5$	0 18327
r_6	0.35	t_6	0.030	$l\ \mu_6$	0 02624
r_7	.∞	t_7	0 065	$l\ \mu_7$	9 79049
r_8	-0 23	t_8	0 155	$l\ \mu_8$	0 18327
r_9	.∞	t_9	0 006	$l\ \mu_9$	9.81673
r_{10}	-0 29	t_{10}	0 025	$l\ \mu_{10}$	0.19033

The distance t_7 is adjustable by the collar, and is given by M^r Tolles as 0 07 This leaves the spherical aberration slightly over-corrected, which may be better for the performance of the objective than 0.065 which makes it aplanatic

R Keith

Computation

$l\ h_1$	9.34242	D_4	2 63767	$l\ D_7$	9 99119	D_{10}	0.05775	$l(\mu_2-1)\frac{1}{r_2}$	9 34503	Diff	1 07499
$l\ r_1$	-9.71600	S_4	1755	$\epsilon_6-\theta_6$	-49°54'19"	S_{10}	0.035	Gauss	0 18181	$l\ \mu_6\frac{1}{u_7}$	-0 28710
$l\ \sin\theta_1$	-9 62642	D_4+S_4	4 39267	ϵ_6	-18°44'42"	$D_{10}+S_{10}$	0 02275	$cl(u_2+t_1)$	-9.81094	$l\ \mu_6$	0.02624
ϵ_1	1°15'38"	$l(D_4+S_4)$	0.64273	$\epsilon_7-\theta_6$	-46°3'54"	$l(D_{10}+S_{10})$	8.35698	Diff	0.46591	$l\ u_7$	-9 73914
θ_1	-25°1'45"	$l\ \sin\epsilon_4$	-8.90186	θ_6	31°9'37"	$l\ \sin\epsilon_{10}$	-9 83338	$l\ \mu_2\frac{1}{u_3}$	-9 62913	u_7	-0.54845
$\epsilon_1-\theta_1$	26°17'23"	$cl\ r_4$	9.74473	ϵ_7	-14°54'17"	$cl\ r_{10}$	-1 53760	$l\ \mu_2$	0 03684	t_6	0.03
$l\ \sin(\epsilon_1-\theta_1)$	9.64632	$l\ \sin(\epsilon_4-\theta_4)$	-9 28932	D_7	0 97992	$l\ \sin(\epsilon_{10}-\theta_{10})$	9.72796	$l\ u_3$	-0 40771	u_7+t_6	-0.51845
$l\ \frac{1}{\mu_1}$	9.81673	$l\ \frac{1}{\mu_4}$	0 18327	S_7	0.38	$l\ \frac{1}{\mu_{10}}$	9 80967	u_3	-2.55690	$l(u_7+t_6)$	-9 71471
$l\ \sin(\epsilon_2-\theta_1)$	9.46305	$l\ \sin(\epsilon_5-\theta_4)$	-9.47259	D_7-S_7	0.59992	$l\ \sin(\epsilon_{11}-\theta_{10})$	9.53763	t_2	0.02	$l\ \mu_7$	9 79049
$l\ r_1$	-9 71600	$l\ r_4$	0 25527	$l\ \sin\epsilon_7$	-9 41029	$l\ r_{10}$	-8.46240	u_3+t_2	-2 53690	$l\ u_8$	-9 50520
$l\ \operatorname{Cosec}\epsilon_2$	-0 84870	$l\ \operatorname{Cosec}\epsilon_5$	-0.73449	$l\ \frac{1}{\mu_7}$	0.20951	$l\ \operatorname{Cosec}\epsilon_{11}$	0 08616	$l(u_3+t_2)$	-0 40430	u_8	-0 32004
$l\ D_2$	0.02775	$l\ D_5$	0 46235	$l\ \sin\epsilon_8$	-9 61980	$l\ D_{11}$	8 08619	$l\ \mu_3$	9 96316	t_7	0.065
$\epsilon_1-\theta_1$	26°17'23"	$\epsilon_4-\theta_4$	-11°13'34"	ϵ_8	-24°37'30"	$\epsilon_{10}-\theta_{10}$	32°18'40"	$l\ u_4$	-0 36746	u_8+t_7	-0.25504
ϵ_1	1°15'38"	ϵ_4	-4°34'32"	$l(D_7-S_7)$	9.77809	ϵ_{10}	-42°57'2"	u_4	-2.33056	$l(\mu_8-1)$	9 72016
$\epsilon_2-\theta_1$	16°53'3"	$\epsilon_5-\theta_4$	-17°18'14"	$l\ \tan\epsilon_7$	-9.42510	$\epsilon_{11}-\theta_{10}$	20°10'21"	t_3	0.045	$l\ r_8$	-9.36173
θ_1	-25°1'45"	θ_4	6°39'2"	$l\ \cot\epsilon_8$	-0.33879	θ_{10}	-75°15'42"	u_4+t_3	-2.28556	$l(\mu_8-1)\frac{1}{r_8}$	-0 35843
ϵ_2	-8°8'42"	ϵ_5	-10°37'12"	$l\ D_8$	9.51204	ϵ_{11}	-55°5'51"	$l(\mu_4-1)$	-9 53689	Gauss	0 19925
D_2	1.06598	D_5	2.89968	D_8	0.34837	D_{11}	0.01220	$l\ r_4$	0.25527	$cl(u_8+t_7)$	-0.59339
S_2	-.788	S_5	2.160	S_8	-0.295	S_{11}	-0.004	$l(\mu_4-1)\frac{1}{r_4}$	-9 28162	Diff	0 23496
D_2-S_2	1.85398	D_5-S_5	0.73968	D_8+S_8	0.05337	$-(D_{11}-S_{11})=F$	-0.01620	Gauss	0 15750	$l\ \mu_8\frac{1}{u_9}$	-0 79264
$l(D_2-S_2)$	0.26810	$l(D_5-S_5)$	9.86904	$l(D_8+S_8)$	8.72730			$cl(u_4+t_3)$	-9 64101	$l\ \mu_8$	0.18327
$l\ \sin\epsilon_2$	-9.15130	$l\ \sin\epsilon_5$	-9.26551	$l\ \sin\epsilon_8$	-9.61980	For rays near the		Diff	0.35939	$l\ u_9$	-9.39063
$cl\ r_2$	0 39794	$cl\ r_5$	-0 45593	$cl\ r_8$	-0.63827	axis use the formula		$l\ \mu_4\frac{1}{u_5}$	-9 79851	u_9	-0.24583
$l\ \sin(\epsilon_2-\theta_2)$	-9 81734	$l\ \sin(\epsilon_5-\theta_5)$	9 59048	$l\ \sin(\epsilon_8-\theta_8)$	8 98537	$\frac{\mu_1}{u_2} = \frac{\mu_1-1}{r_1} + \frac{1}{u_1}$		$l\ \mu_4$	9 81673	t_8	0.155
$l\ \frac{1}{\mu_2}$	9 96316	$l\ \frac{1}{\mu_5}$	9.81673	$l\ \frac{1}{\mu_8}$	9 81673			$l\ u_5$	-0 01822	u_9+t_8	-0.09083
$l\ \sin(\epsilon_3-\theta_2)$	-9.78050	$l\ \sin(\epsilon_6-\theta_5)$	9.40721	$l\ \sin(\epsilon_9-\theta_8)$	8.80210	r_1	-9.71600	u_5	-1 04265	$l(u_9+t_8)$	-8.95823
$l\ r_2$	9 60206	$l\ r_5$	-9.54407	$l\ r_8$	-9.36173	$l\ \operatorname{Vers}\theta_1$	8.97270	t_4	0 01	$l\ \mu_9$	9 81673
$l\ \operatorname{Cosec}\epsilon_3$	-1.13498	$l\ \operatorname{Cosec}\epsilon_6$	-0.49301	$l\ \operatorname{Cosec}\epsilon_9$	-0.34989	$l\ r_1\operatorname{Vers}\theta_1$	-8.68870	u_5+t_4	-1 03285	$l\ u_{10}$	-8 77496
$l\ D_3$	0.51754	$l\ D_6$	9 44429	$l\ D_9$	8.51372	Gauss	0.00213	$l(\mu_5-1)$	9.72016	u_{10}	-0.05956
$\epsilon_2-\theta_2$	-41°2'44"	$\epsilon_5-\theta_5$	22°55'19"	$\epsilon_8-\theta_8$	5°32'54"	$l\ 10\cos\epsilon_1$	0.99989	$l\ r_5$	-9 54407	t_9	0.006
ϵ_2	-8°8'42"	ϵ_5	-10°37'12"	ϵ_8	-24°37'30"	Diff	2.31119	$l(\mu_5-1)\frac{1}{r_5}$	-0.17609	$u_{10}+t_9$	-0 05356
$\epsilon_3-\theta_2$	-37°6'12"	$\epsilon_6-\theta_5$	14°47'49"	$\epsilon_9-\theta_8$	3°38'6"	$l\ u_1$	0.99776	Gauss	0.21029	$l(\mu_{10}-1)$	9.74030
θ_2	32°54'2"	θ_6	-33°32'31"	θ_8	-30°10'24"	$l(\mu_1-1)$	9 72016	$cl(u_5+t_4)$	-9 98597	$l\ r_{10}$	-8.46240
ϵ_3	-4°12'10"	ϵ_6	-18°44'42"	ϵ_9	-26°32'18"	$l(\mu_1-1)\frac{1}{r_1}$	-0.00416	Diff	0.19012	$l(\mu_{10}-1)\frac{1}{r_{10}}$	-1.27796
$l\ \sin\epsilon_3$	-8 86502	D_6	0.27816	D_9	0.03264	Gauss	0.04554	$l\ \mu_5\frac{1}{u_6}$	-0.39238	Gauss	0.29764
$l\ \frac{1}{\mu_3}$	0.03684	S_6	-0.555	S_9	-0.075	$l\ \frac{1}{u_1}$	9.00224	$l\ \mu_5$	0.18327	$cl(u_{10}+t_9)$	-1 27116
$l\ \sin\epsilon_4$	-8.90186	D_6-S_6	0.83316	D_9-S_9	0 10764	Diff	1.00192	$l\ u_6$	-9.79089	Diff.	0.00680
ϵ_4	-4°34'32"	$l(D_6-S_6)$	9.92073	$l\ \sin\epsilon_9$	-9 65011	$l\ \mu_1\frac{1}{u_2}$	-9 95862	u_6	-0.61786	$l\ \mu_{10}\frac{1}{u_{11}}$	-1.57560
D_4	3.29261	$l\ \sin\epsilon_6$	-9.50699	$l\ \frac{1}{\mu}$	0 18327	$l\ \mu_1$	0 18327	t_5	0.145	$l\ \mu_{10}$	0.19033
S_3	.42	$cl\ r_6$	0 45593	$l\ \sin\epsilon_{10}$	-9.83338	$l\ u_2$	-0.22465	u_6+t_5	-0.47286	$l\ u_{11}$	-8.61473
D_3-S_3	2 87261	$l\ \sin(\epsilon_6-\theta_6)$	9.88365	ϵ_{10}	-42°57'2"	u_2	-1.67745	$l(\mu_6-1)$	8.79435	u_{11}	-0.04118
$l(D_3-S_3)$	0.45828	$l\ \frac{1}{\mu_6}$	9.97376	$l(D_9-S_9)$	9 03197	t_1	0 132	l [illegible]	9.54407	t_{10}	0.025
$l\ \tan\epsilon_3$	-8 86619	$l\ \sin(\epsilon_7-\theta_6)$	9 65741	$l\ \tan\epsilon_9$	-9.69846	u_2+t_1	-1.54545	$l(\mu_6-1)\frac{1}{r_6}$	9 25028	$u_{11}+t_{10}=f$	-0.01818
$l\ \cot\epsilon_4$	-1 09675	$l\ r_6$	-0.54407	$l\ \cot\epsilon_{10}$	-0.03110	$l(\mu_2-1)$	8.94709	Gauss	.03817	F	-0.01620
$l\ D_4$	0.42122	$l\ \operatorname{Cosec}\epsilon_7$	-0.58971	$l\ D_{10}$	8 76153	$l\ r_2$	9.60206	$cl(u_6+t_5)$	-0 32527	$f-F=Ab.$	+0.00002

W. West & Co lith.

Fig. 1.
Bacterium termo

Fig. 2.
Spirillum volutans

Fig. 3.
Vibrio rugula.

Fig. 4.
Spirillum undula

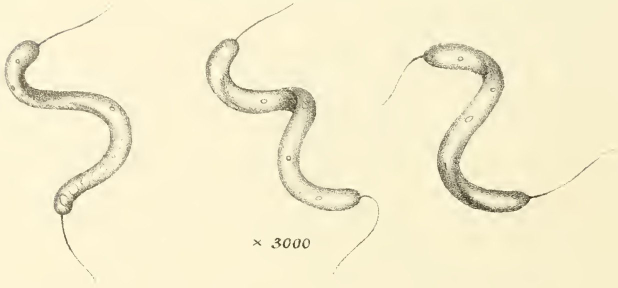
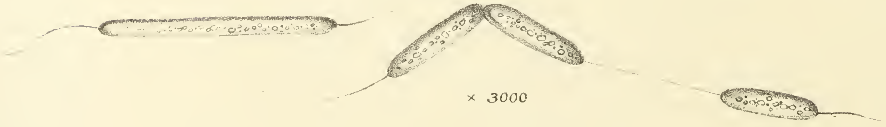


Fig. 5.
Bacillus ulna

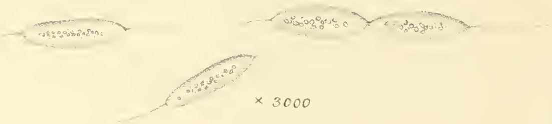


W. H. Dallinger del ad nat.

W. West & Co. lith.

Fig. 6.

Bacterium lineola.



× 3000

Fig. 7.

× 500

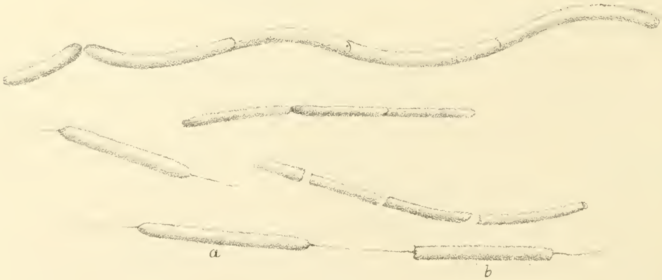
Fig. 8.

× 700

Fig. 10

Fig. 9.

Bacillus subtilis.



× 4000

Fig. 12.

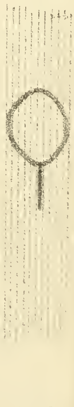
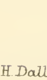


Fig. 11.



W.H. Dallinger del ad nat.

W. West & Co lith.

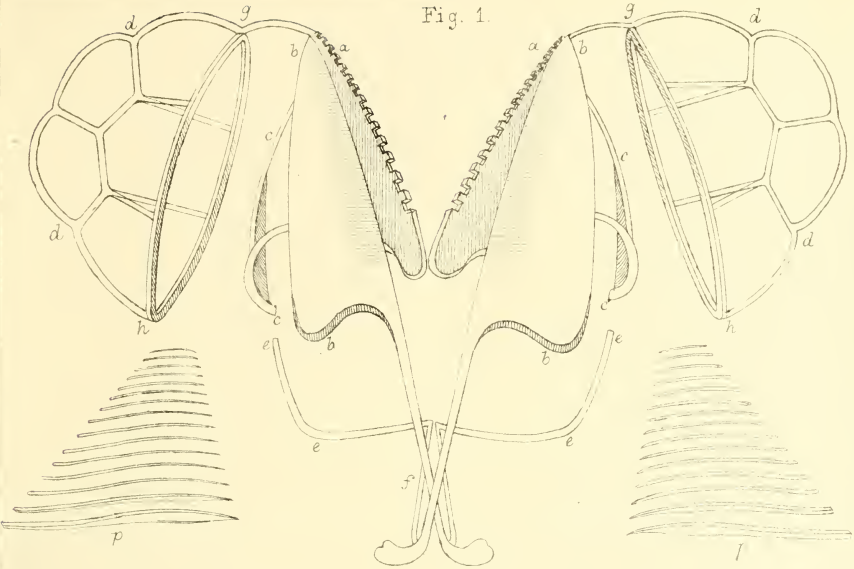


Fig. 1.

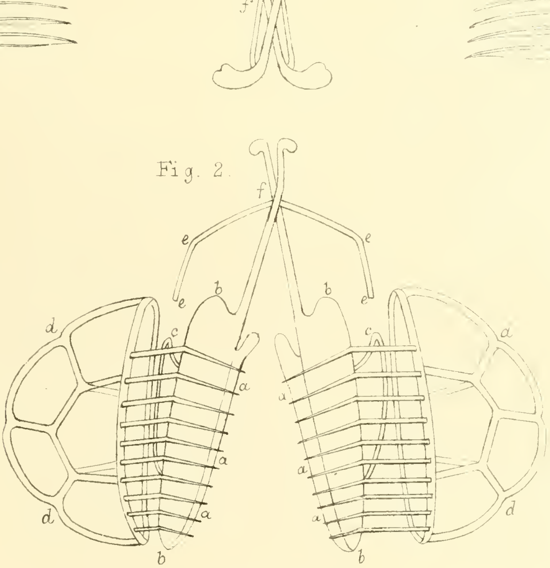


Fig. 2.

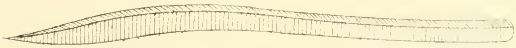


Fig. 5.

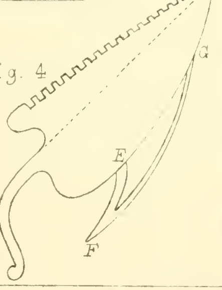


Fig. 4

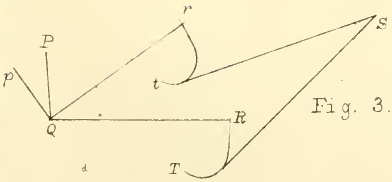


Fig. 3.

F.A.B. del.

W. West & Co. lith.

Framework of Mastax of Melicerta Ringens.

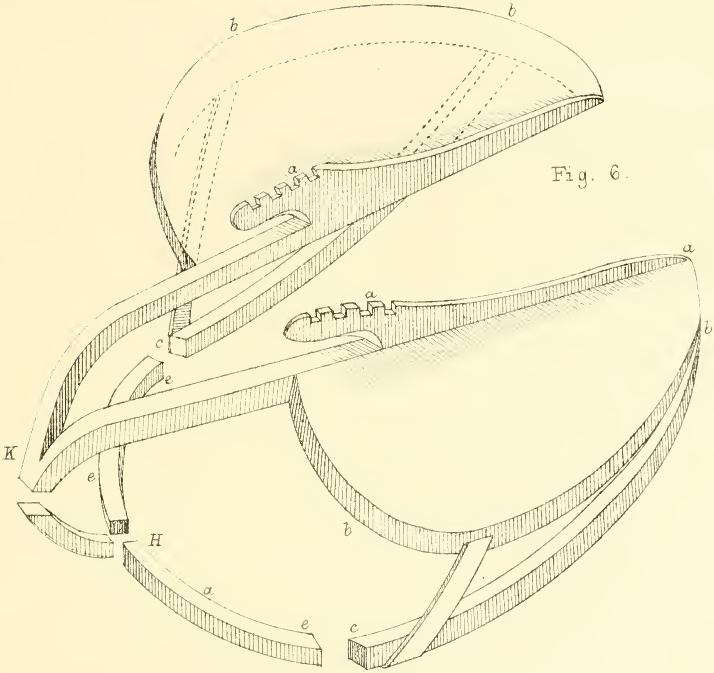


Fig. 6.

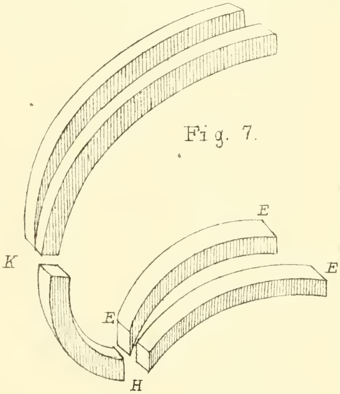


Fig. 7.

Fig 8.

Fig. 9.

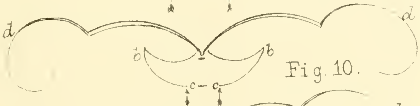


Fig. 10.

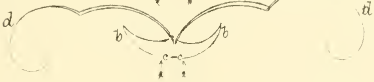


Fig. 11.

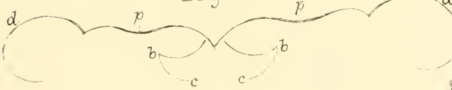
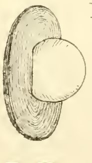


Fig 12.



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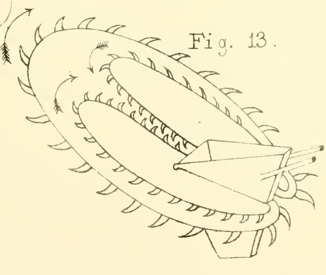
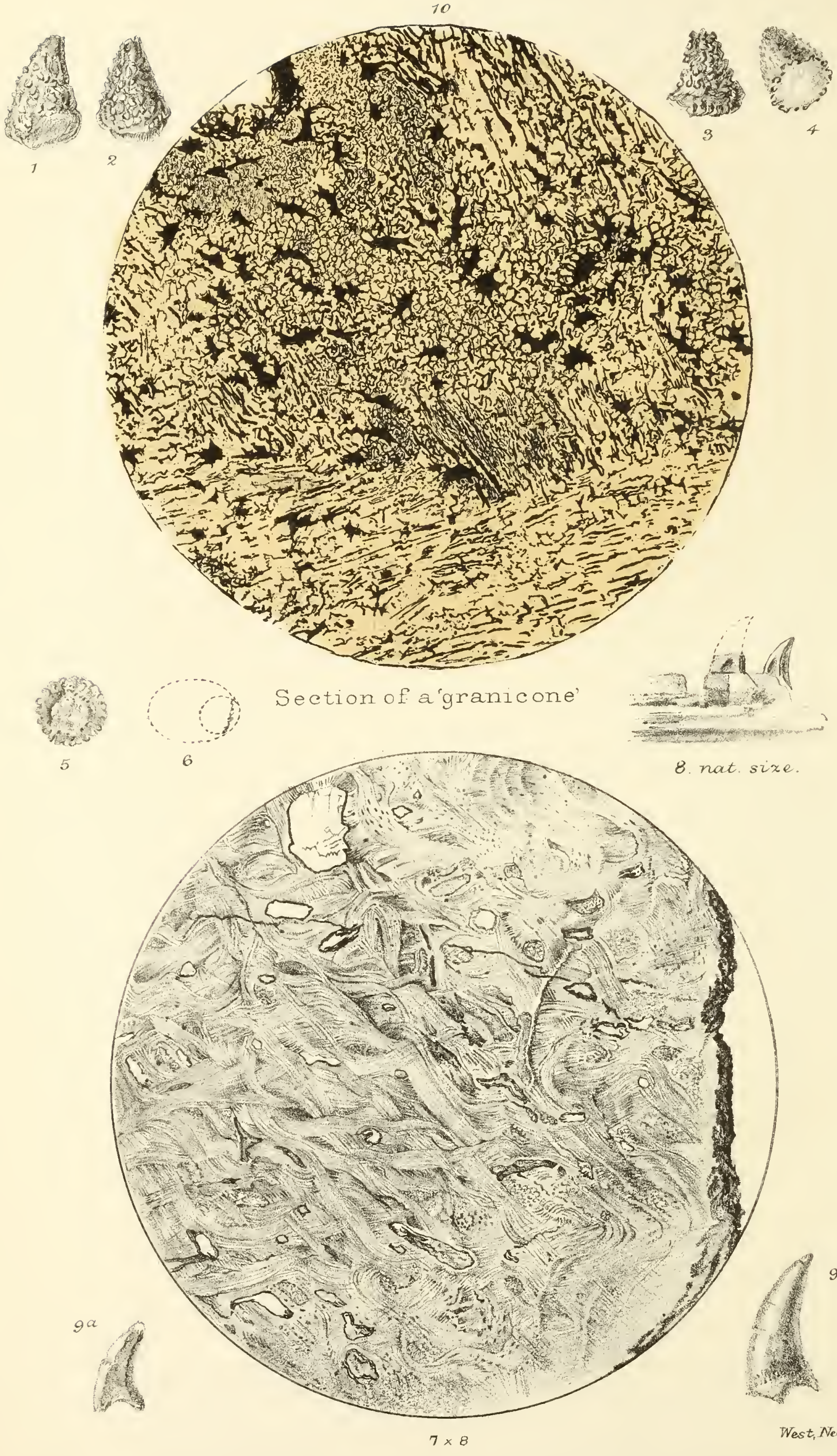


F.A.B. del.
W West & Co. lith.

Mastax of Conochilus volvox.

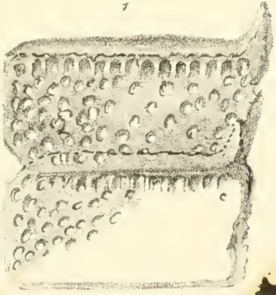


Section of a 'granicone'

8. nat. size.

West, Newman & Co. lith

Dermal tubercles ('granicones') & teeth (Nuthetes destructor).


2/1

2

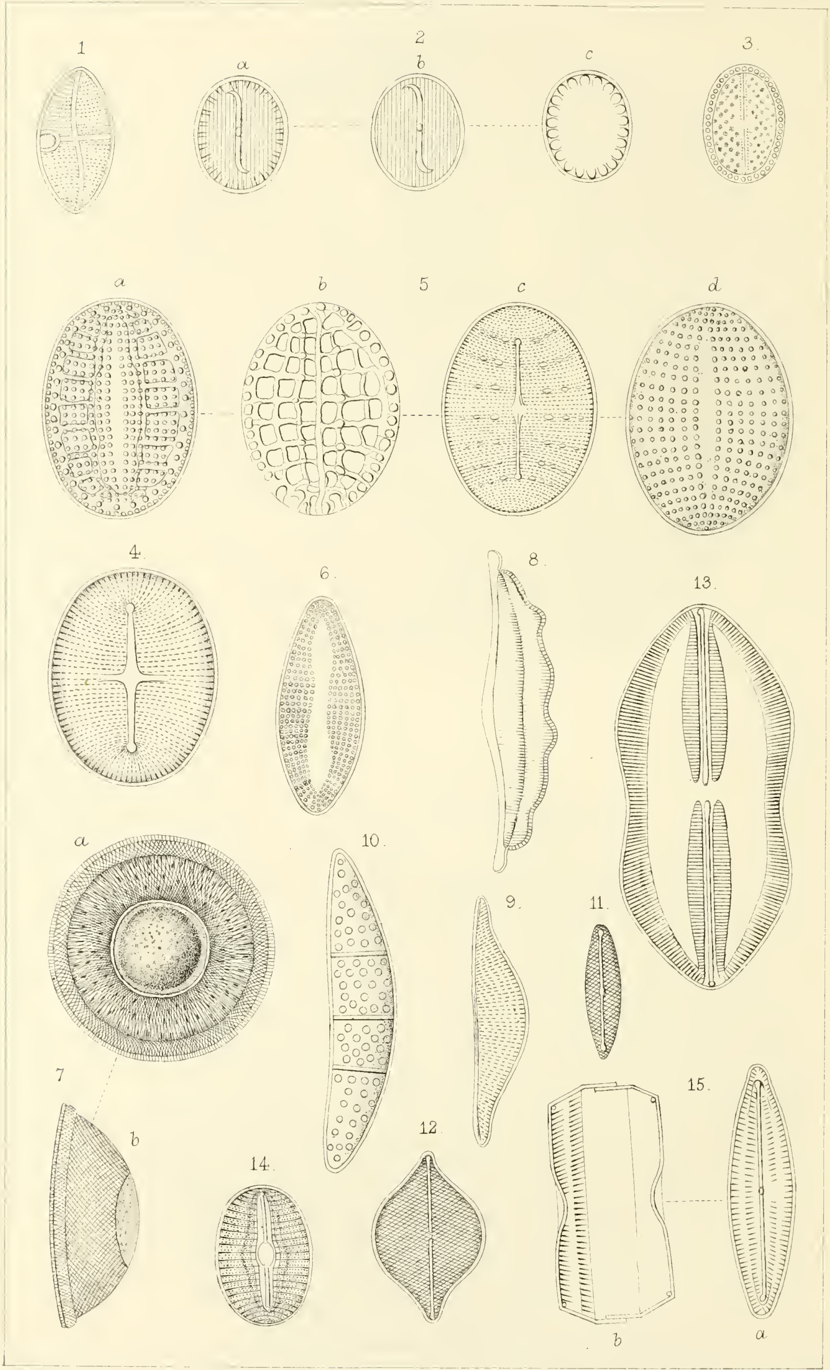

4 x 333, about.


1
Nat size.


3 x 33, about

West, Newman & Co lith.

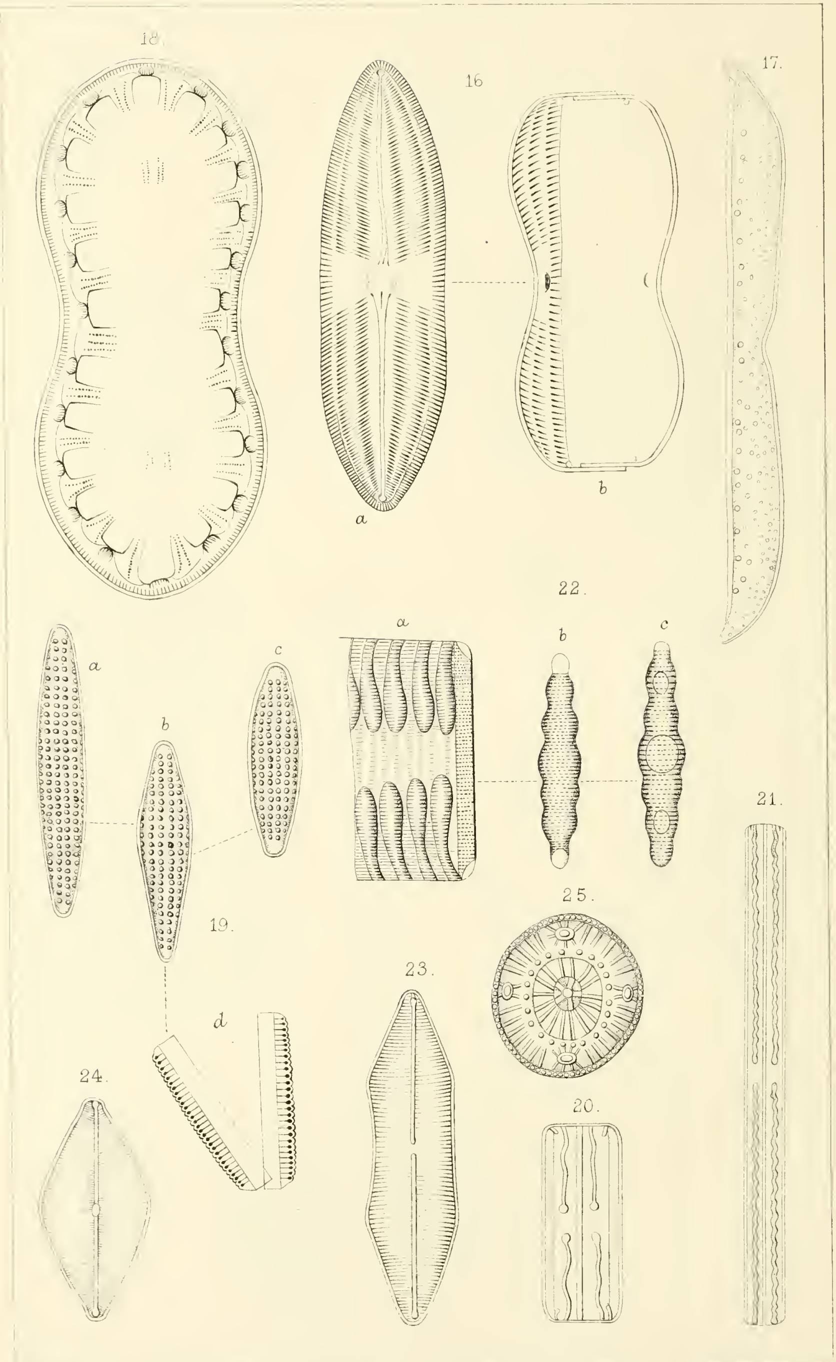
Dermal scutes (Theriosuchus pusillus).



P. Petit del.

W. West & Co. lith.

New Genera and Species of Diatomaceæ.

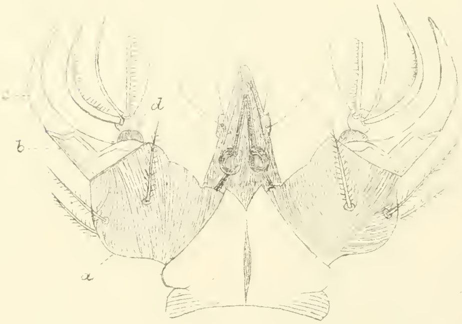


T. West del.

W. West & Co. lith.

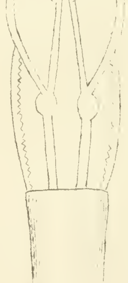
New Genera and Species of Diatomaceæ.

1



2

3



4

A. Michael del.

W. West & Co. sc.

Cheyletus Venustissimus

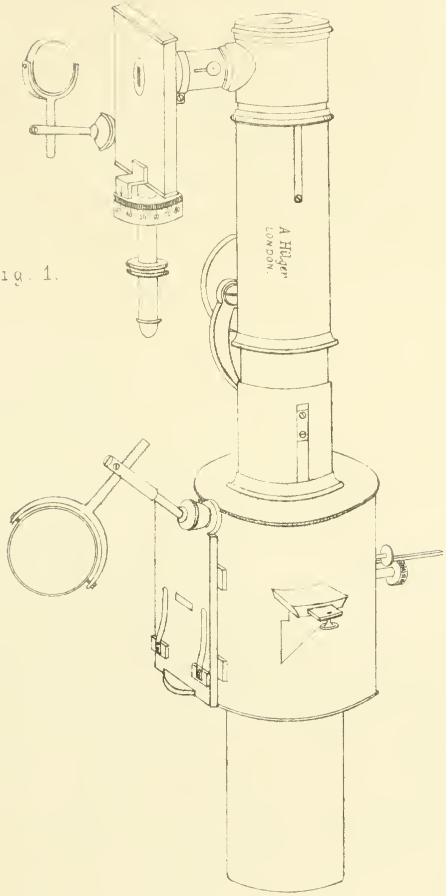


Fig. 1.

Fig. 2.

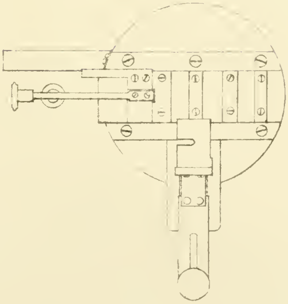
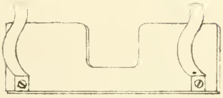


Fig. 3.



T.H. Ward [illegible] del.

West Newman & Co. imp.

New Microspectroscope