ARACHNOIDISCUS

An account of the genus, comprising its history, distribution, development and growth of the frustule, structure and its examination and purpose in life, and a key to and descriptions of all known species, illustrated.

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PREFACE

ARACHNOIDISCUS is such a beautiful genus of diatomaceæ and so familiar to most microscopists that the writer was greatly surprised and disappointed to find that no adequate account of the genus had been published, when he desired, some years ago, to name a few undetermined specimens in his possession. For upon referring to the monograph of the genus in De Toni, *Sylloge Algarum*, vol. 2, p. 1311, this was found to be utterly useless for naming the species, either from the descriptions, which give no real distinctive characters, and there is no key to the species, or from the figures quoted under them. Because, upon consulting those and other figures I was astonished to find figures of what is obviously the same species named differently, and other figures of what are obviously distinct species bearing the same name. Also, upon examining numerous named slides these were often found to be quite wrongly determined; sometimes the same species occurred under different names, and sometimes the same name was given to very distinct species. For example, as I write I have before me four slides, all named "*A. indicus*." All four are entirely different from each other and not one of them is correctly named! It therefore became necessary to carefully examine all the original figures and descriptions that I could find in order to discover to which diatom some of the names really belonged before attempting to name any of the specimens. This examination at once disclosed that the nomenclature in Schmidt's Atlas and works of other writers upon diatoms is quite untrustworthy and that the genus greatly needed revision. This induced me to prepare the present account of the genus, whereby it is hoped a more correct nomenclature of the species may be obtained. It includes an account of all the species and figures I have seen, but is not a complete monograph of the genus, as I am certain there must be other species contained in some of the large collections that I have not seen and which are not figured, and there may also be other figures than those herein quoted that I have not seen.

The erroneous names found in books and upon slides seem to indicate either carelessness or incompetence on the part of the namer. This may seem a harsh indictment, but anyone who will take the trouble to compare the original figure of a species with those figures or specimens that bear the same name, will often find the above statement amply justified. It is the custom of the practical botanist when he finds that a plant he has to name bears a very close resemblance to another, to first ascertain if it is native of the same or a different country, and if from a different country, he dissects and critically compares the various parts of both plants to ascertain if they are actually the same or a different species ; but evidently some diatomists do not do so with their plants. If two diatoms bear the slightest resemblance to one another they are too often considered to be the same species ; locality is not taken into account, and structure is either not examined or entirely ignored. For example, I find in various books no less than ten species differing structurally all figured as being *A. Ehrenbergii*, or varieties of it, and six species are figured as being *A. indicus*, or varieties of it, not one of the latter being correctly named! This is not as it should be; a diatom cannot be dissected, but each species has a definite structure, varying within limits, whereby it can be clearly distinguished from others allied to it. It seems that Van Heurck and others regard similarity of appearance alone as indicating specific identity. For, in his "Treatise on the Diatomaceæ" (p. 100), Van Heurck, after stating that *Navicula* (*Vanheurckia*) *rhomboides* found in fossil deposits "is identically the same as that found in the living state to-day," remarks that "*Arachnoidiscus Ehrenbergii*, which is still found inhabiting the Sea of Japan, and occurs in all respects the same in the deposits of Hungary, which date back to the remote tertiary period, when a tropical sea covered central Europe, again confirms this assertion." But what are the facts? The true *A. Ehrenbergii* of western N. America, so far as known to me, is not found in the Sea of Japan, but is represented there by *A. sendaicus*, which is perfectly distinct in structure and appearance from the only Hungarian species (*A. hungaricus*) I have seen.

If one looks at the figure of *A. Ehrenbergii* on pl. 4, fig. 5, and of *A. hungaricus* and *A. cognatus*, on pl. 5, figs. 6 and 7, it will be seen that all three bear such a close resemblance to one another that some may be inclined to say: "Pooh, they are not distinct species." And even if seen under a microscope a casual observer might possibly overlook their structural difference. But a specialist ought not to do so, as the difference is considerable and quite evident when looked for, and being constant is specific. Their surface contour (i.e., external sculpture) is often different when seen and compared under a Wenham or other binocular that gives a good stereoscopic view of an object; some Continental eyepiece-binoculars do not give a stereoscopic perspective and are useless for that purpose. *A. Ehrenbergii* and its Japanese representative *A. sendaicus*, have a connecting membrane at the centre on the inner surface, and well-marked tertiary rays. While in *A. hungaricus* and *A. cognatus* there is no connecting membrane, and tertiary rays are absent or very obscure, except when growth is taking place and tertiary rays appear temporarily where secondary rays are growing in to become primary rays. The cells also, of these species, differ in small details, which cannot be disregarded. Such structural differences are recognised by competent botanists to constitute sound specific characters, especially when supported by a wide difference in locality.

The figures illustrating this book show only the general appearance of the species, as it is not possible to represent all details as the eye sees them in one photographic view, but the structural details will be found in the descriptions or in the notes under them.

It is well known that many fresh-water diatoms and plants of a higher type are widely distributed in many and distant parts of the world, which is easily explained by the fact that birds and other creatures, whirlwinds, oceanic currents, etc., have transported them to various localities during the vast periods of time they have existed. But there are others that are of fixed habit, or which for some other unknown reason do not seem ever to have been capable of being transported from one region to another. And marine species of fixed habit, as is the case with *Arachnoidiscus*, also follow this rule in the majority of cases. This is all well known, and diatoms are dependent for their distribution upon the same factors that govern the distribution of other plants, although diatomists do not seem to have taken them into consideration when naming the species.

From the descriptions given it would appear that the only characters recognised for the distinction of species of *Arachnoidiscus* are size, number of rays, and measurements of the size of the cells. It is quite necessary to mention these in a description, but alone they are quite useless for the discrimination of species, because the same species will vary in these particulars according to age, sex, etc.; for example, a young *Arachnoidiscus* is of smaller size and always has fewer rays than an old one. And a recent discovery indicates that the sexes differ in size, see under *A. ornatus* There are, however, absolute characters (varying within limits) which can be easily recognised that distinguish the species from each other, although they do not seem to have been recognised or hitherto employed. But it is hoped that by their means fellow microscopists may be able to clear up some of the confusion of names that will probably be found to exist in their collections.

As the achievement of this work has been rendered possible only through the kindness of other microscopists, some of them personally unknown to me, who have aided me in my study of this genus, I hereby offer them my grateful thanks for entrusting some of their valuable slides to my care. But I specially desire to record my great indebtedness to Mr. F. Adams for the privilege of being able to consult his exceedingly fine collection in which are several species I should otherwise not have seen. To Mr. J. A. Long, ofFerncliffe, Cleaseby Road, Menston, Leeds; and Mr. H. R. S. Williams, of Holmlea, The Moss, Altrincham, for the specimens they have specially mounted and given or

lent to me ; and to the authorities at the British Museum for the help they have so cordially given when consulting the vast collection there, I wish to express my gratitude.

As I find so many misidentifications have been made in the determination of the species of this genus, and it becomes quite impossible to be quite certain what species may be intended in various books by the mention of a name or a brief description without a figure, I have therefore, with a few exceptions where there can be no doubt, omitted all reference to such descriptions or names.

With reference to the reproductions of the photographs which illustrate this book, I would like to say that however good a photograph may be it can never represent the beauty and delicacy of a diatom as the eye sees it through a microscope. Of this *A. Longii*, pl. 3, fig. 1, is a good example, as it in no way represents the charm of this species as seen with the eye, and yet it is a good photograph of this very distinct species, but is in some way blurred by some peculiarity of the mounting medium which the camera has detected but the eye does not. All but one of these photographs have been very kindly prepared for me by Mr. W. N. Ellis, of Appledore, N. Devon, who has devoted much time and evinced considerable skill in their preparation, and to whom I offer my most grateful thanks.

ARACHNOIDISCUS

History.

ARACHNOIDISCUS affords a peculiar case of a genus that has not been always credited to its real author, but to one who used the name second-hand without knowledge of who first gave the name. As its history is perhaps unfamiliar to modern microscopists the following account may have some interest.

The discovery of the first known species of this genus was made at the beginning of the year 1847, and the name *Arachnoidiscus* given to it, as will presently be detailed. But it was first published by Ehrenberg under the name of *Hemiptychus ornatus* in *Bericht Akad, Berlin*, 1848, p. 7, and noted in the *Annals and Magazine of Natural History*, 1848, vol. 1, pp. 392–394. The next year Ehrenberg, in *Bericht Akad, Berlin*, 1849, p. 64, states that Prof. Bailey of New York had pointed out to him that as the name *Hemiptycha* had already been applied to a genus of insects, the name *Hemiptychus* (which is only the masculine form of the same name) could not be used for this genus of diatoms, and that the name *Arachnoidiscus* should be substituted for it. Therefore, at that place, Ehrenberg, quite correctly in accord with the rules of nomenclature then in force, changed the name *Hemiptychus* to *Arachnoidiscus*, and added a description of a new species (*A. Ehrenbergii*, Bailey) sent to him by Prof. Bailey. This was the first publication of the name *Arachnoidiscus* (there spelled *Arachnodiscus*), which by some authors has been credited to Bailey. But Walker Arnott, in an article entitled "On *Arachnoidiscus*," published in the *Quarterly Journal of Microscopical Science*, 1858, vol. 6, p. 159, states on p. 161 that Bailey repudiated the authorship for the name, for in a letter dated July 27th, 1853, he wrote: "I see that Smith in his Brit. Diat. gives me as the founder of the genus. This is not correct, but the species is mine, and it is very different from the *Arachnoidiscus japonicus* with which

Smith confounds it." Clearly, then, as Ehrenberg states that he got the generic name from Bailey, and Bailey denies the authorship of it, the name *Arachnoidiscus* must have been in circulation and the real author of it unknown to them both. However, on the same page, Arnott clears up this point by adding: "The founder of the genus was Mr. H. Deane of Clapham, and it was first noticed in a paper read by him before the Microscopical Society on March 17th, 1847. This paper was not published, and although it contained a general description of the disk, no distinguishing character was given. Mr. Shadbolt, on November 14th, 1849, read a paper, 'On the Structure of the Siliceous Lorica of the genus *Arachnoidiscus*,' and confirmed the appellation."

On p. 188 of the same volume above quoted, Henry Deane himself adds to Walker Arnott's account the following: "On March 17th, 1847 (just eleven years last Wednesday), I read a short unscientific notice 'On the occurrence of *Arachnoidiscus* on an edible fucus from Japan,' at the end of which, on a question put by our friend John Quekett, I said 'From the circumstance of these disks presenting a reticulated appearance similar to the webs of some species of spiders, I propose to call the genus *Arachnoidiscus* and the species above mentioned *japonicus*.' My notice did not give a scientific description of the genus intelligible to anyone, and therefore, as I have since learned, I have no claim to it. . . . Bailey gets the credit, perhaps according to rule, but I cannot help feeling—waiving my having suggested the name—that Shadbolt has the prior claim, as he read a paper on the subject, November 14th, 1849 (*Trans. Micr. Soc.*, 1852, vol. 3, p. 49). I have an impression that the first specimens Bailey ever had are mine, forwarded to him by Mr. Marshall."

This last statement probably explains how Bailey became acquainted with the name *Arachnoidiscus*. The only published account of the meeting at which Mr. Deane read that paper that I have been able to find is in the *Phytologist*, 1847, p. 818, where it states Mr. Deane read two papers at that meeting, one on Fungi, the other on the diatom, which is as follows:

"On the source whence siliceous cases of Infusorial Animalcules in Ichaboe Guano are derived. After premising that aquatic birds in addition to fish feed largely on marine plants, he proceeded to state that on a plant of this kind from Japan, used exclusively in China as an ingredient in soups, the name of which he had been unable to ascertain, he had found imbedded in great abundance, round disks precisely similar to those found in the guano. He had also found them on another marine plant from Mauritius (*Thamnophora Telfaria*)." It will be noticed that the name *Arachnoidiscus* is carefully omitted from the account, thus robbing Deane of the recognition due to him.

This is probably a unique case of authors trying to shirk the responsibility of a generic name and one that is eminently suitable and applicable to the organisms. Taking all circumstances into consideration it seems only right that the name *Arachnoidiscus* should be credited to Deane, as was done by Pritchard in 1852 (*Infusoria*, ed. 2, p. 318).

A. Mann (in *Contributions from the United States National Herbarium*, vol. 10, p. 266, published July, 1907) has, however, sought to revive and substitute the name *Hemiptychus* for the familiar *Arachnoidiscus*, a change that in the opinion of the writer is not justified. For I cannot agree that the name *Hemiptychus* has any claim to recognition, as it is the same word as *Hemiptycha* in the masculine gender and was published later. It is a rule of nomenclature that two different genera or two different species in the same genus cannot bear the same name, and when the same name has inadvertently been applied to two different genera or species the first to be published with that name shall retain it, while that later published under that name shall have the name changed. This conforms with what has been done. If such a revival of the name *Hemiptychus* is accepted, then there is nothing to prevent anyone from giving to a new genus of diatoms the name *Hemiptychum* and thus completing the triad of genders, or in addition to the genus *Actinoptychus*, we might, with equal right have also *Actinoptycha* and *Actinoptychum*, thus reducing nomenclature to an absurdity, as if it were not confusing enough already.

Other accounts of the history of this genus are as follows: On the genus *Arachnoidiscus*, F. Kitton, in *Science Gossip*, 1875, vol. 11, p. 121—*Arachnoidiscus ornatus*, F. B. Saxton, in *English Mechanic*, 1919, vol. 110, p. 198—*Arachnoidiscus*, F. B. Saxton, in *English Mechanic*, 1920, vol. 110, p. 285.

Structure and its Examination.

In addition to the brief general structure which will be found detailed under the generic characters, the following particulars should be noted, and also that I have had to give names to structures others seem not to have noticed.

As there stated, the *frustule* is shaped like a shallow flat pill-box. When alive it appears that it is always the larger *valve* or that corresponding to the lid of a pillbox that is attached to the seaweed, the smaller valve being upwards and free, i.e., like a pillbox upside down with the lid cemented to the object on which it rests.

As the two *surfaces* of each valve differ in character, in studying this genus it is important to know which surface is being examined, as the want of this necessary knowledge has caused the two surfaces of valves of the same diatom to be mistaken by experts in Schmidt's *Atlas* for two different species! When viewed binocularly the outer and inner surfaces of a valve can easily be determined. But monocularly it is not quite so easy; the best way to determine if the outer or inner surface is next the cover-glass is to note if the marginal ledge (see p. 15) comes into focus before the cells (see p. 15) are clearly seen, when it is the inner surface that is upwards; but if the marginal cells come into view before the marginal ledge or the rays or together with the rays, then it is the outer surface that is next the cover-glass.

The *rays* are the black or white or black-edged partitions that radiate from the central part to the margin of the valve and act as supports or strengthening girders to the shell. They are of three denominations. The longer are the *primary rays*. Between each pair of primary rays is a shorter one, the *secondary ray*; and midway between each primary and secondary ray is present in some species and absent from others a *tertiary ray* formed of a short line or a dot much stouter than the numerous other small lines or dots around the margin. The number of rays varies both in different species and in different specimens of the same species. Young specimens having fewer rays than adult ones, because with the age and growth of the shell the rays increase in number as described later under "Development and growth." On the outer surface the rays are not raised above the surrounding solid parts and are sometimes depressed in shallow furrows. On the inner surface the rays, in some species, are not raised above the surface except at the tips (i.e., marginal ends), and in others are raised for a part or the whole of their length and often girder-shaped. Wherever prominent, either at the tips or all along, diffraction images are produced, causing them to appear black or black-edged where raised above the surface. And when raised all along they are sometimes connected at the centre on the inner surface by a thin membrane, somewhat like the "web" or membrane connecting the toes of a duck's foot, which may be termed the *connecting membrane.*

The *marginal ledge* consists of a membrane at the margin on the inner surface of the valve connecting the primary and secondary rays and forming a sort of ledge or shelf all round the marginal part of the valve, and is broad or narrow according to the species. In some species just beneath this membrane is a similar membrane connecting the tertiary with the primary and secondary rays.

The *cells* * are the markings described by other writers as "dots, beads, pearls, granules, alveoles or costæ," because their real nature is not well known nor recognised by the majority. In the *English Mechanic* for January 1st, 1915, a writer states of the cells of *Arachnoidiscus* that he is "not able to decide whether they are apertures or not," and asks, "What is the use of all this delicate ornamentation of so small an object?" The

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* This account, in substance, has been published in Watson's *Microscope Record*, September 1932, p. 13, but is included here to make the present description more complete.

account given of them in books such as in West and Fritsch, *Treatise on the British Freshwater Algæ*, is also vague and somewhat misleading. So that it should be clearly understood they are really cavities in the substance of the shell, closed on the outer and inner surfaces by an exceedingly thin membrane, which, probably, is usually not more than 1/200,000th of an inch in thickness. This membrane is always slightly below the level of the general surface of the shell, and sometimes the cells are sunk in distinct pits, or sometimes the *radial spaces* (that is, the partitions separating the cells from one another in a radial direction) are sunk below the level of the *concentric spaces* or partitions separating the cells from one another transversely to the radial spaces, so that the rows of cells between the rays are arranged in series of concentric grooves. These grooves, however, are not easily seen under monocular vision, except under high magnification, but can be readily seen with binocular vision. This arrangement is doubtless to protect these very thin membranes from injury, for I have reason to believe they play a very important part in the life history of every diatom.

In *Arachnoidiscus* and many other genera, and probably in all diatoms, these membranes are dotted, but usually the dots are very difficult to detect; mostly, also, they are very minute, as in *A. Ehrenbergii*, or extremely minute, as in *Pleurosigma formosum*, and require a magnification of 2,000–5,000 diameters to render them visible.

These dots, of course, have long been known to exist on the membranes of the cells of such diatoms as various species of *Triceratium*, *Coscinodiscus*, etc., but I am not aware that their nature or structure has by any other author anywhere been described. Like the cells they have been merely termed dots, or by Otto Mueller, "poroids," and larger dot-like markings "pores." This is an entire misconception due to insufficient magnification and imperfect examination. For the structures termed "pores" and "poroids" by Mueller can be clearly seen under high magnification and careful manipulation not to be holes in the structure, and the pore-like appearance as in *Synedra* is sometimes produced by diffraction images around a solid structure! If a diatom (such as some species of *Triceratium,* in which the dots upon the cell-membrane or membranes are of such a large size as to be easily seen with a 1/6th) be examined, and these dots are magnified 5,000–6,000 diameters and carefully studied, it will be found that they are most certainly not pores (i.e., holes) in the membrane, but are clearly thinner places in that membrane, exactly in the same way that water-marks on paper are thinner spaces in that paper. As this can clearly be seen to be the structure of these large dots, the structure of smaller dots will almost certainly be of a similar nature. I have submitted these membranes to various magnifications up to 8,500 diameters by means of a 1/23rd-inch Zeiss immersion objective and fail to find the slightest trace of an actual pore in any of them; and the various markings that by Mueller and others have been stated to be pores or canals have invariably proved to be nothing of the kind when highly magnified and accurately focussed, although when not correctly focussed diffraction images are seen, and it is these false images that have been accepted as being real structure and misinterpreted into being pores.

Similar dots also occur on the cell-wall of many (and possibly all) Desmids, and these dots also have been declared by various writers to be pores (see West and Fritsch, *Treatise on the British Freshwater Algæ* for references). But I have been quite unable to detect any actual pore in any desmid examined, the so-called "pores" being closed on the outer surface of the desmid by a very thin membrane, but whether these dots are cells in the cell-wall closed on the outer and inner surface by a thin membrane, as they are in diatoms, or whether they merely represent thin places in the cell-wall I am unable to determine, but they are certainly not holes through the cell-wall. Also they are difficult to study because specimens of this group are not mounted in media of high refractive index. The reason I mention desmids here and the point to which I desire to call attention is that both desmids and diatoms are aquatic plants and form two groups that are closely allied to one another, and both groups possess these dots; therefore, as desmids and diatoms live much in the same manner there can be little doubt that the function of the dots is identical in both orders, and I believe that function to be for the purpose of permitting the interchange of fluids and gases between the living organism and its surroundings, acting in a somewhat similar manner to the stomata of more highly organised plants; or in other words the dots may be regarded as a rudimentary type of stomata. It is well known that dense fluids like balsam, styrax, etc., easily penetrate into the cells of a diatom-valve and fill the cavities, and I believe that is easily explained by either the whole membrane closing the cell or by the dots upon it being formed of a very absorbent type of siliceous material, through which fluids and gases can pass as easily as through blotting-paper. That such an absorbent type of silex exists has been demonstrated by the late Prof. Dendy, who discovered that certain siliceous spicules of sponges, which had been boiled in strong acids, swelled greatly when placed in water, which proved that they had absorbed some of the water.

The *arrangement of the cells* in *Arachnoidiscus* varies in different species, but is usually fairly constant for the same species. In some they are arranged in concentric circles from the centre to the margin with the rows between the rays opposite at the rays and forming regular circles, or alternating at the rays and forming broken or irregular circles. In other species the central area is covered with an irregularly arranged mass of cells, and between the rays with either regular or irregular concentric circles; or in others they may be irregularly arranged all over the shell except as to the first two or three circles. These various types of arrangement being, each one, usually constant for each species, constitute good specific characters, although hitherto unused.

The *cells of the first circle* differ on different valves of the same species (see pl. 3, figs. 2–5). On one valve of some species they are linear in shape, and on the opposing valve of the same frustule wedge-shaped or circular, or, in other species, some variant of these three types. This difference in the character of the cells of the first circle seems to indicate that for each valve they perform a different function or different modification of such function.

All the other cells of the shell differ in form from those of the first circle, and as seen at a magnification of 300–600 diameters mostly appear entire, but under a 1/12th oil-immersion lens are, in many cases, seen to be distinctly lobed. The lobing can easily be detected, but to perceive the dots on the cell-membrane requires a good lens combined with high magnification and correct manipulation.

It may be thought there is no necessity to discuss the examination of these or any other diatom in this book, as everyone possessing a microscope would know how to examine them. But this is far from being the case, and true only to a limited extent, as from what I have observed and from various statements and figures that have been published and photographs seen, it is evident there are many microscopists who do not know when a diatom is seen at the correct focus, at least under high magnification, otherwise such terms as "beads," "pearls," "granules," etc., would never have been used, for they are all false effects caused by tricks of lighting and inaccurate focussing! As an illustration I give three figures of the same specimen of *A. ornatus* var. *dispar*, pl. 4, figs. 1–3, representing it as seen at three foci; each might appear correct to some, and perhaps fig. 3 be chosen by many as the right view, but the left-hand side of fig. 1 represents the correct focus. And the figure of *A. clarus*, N.E.Br., on pl. 6, fig. 2, represents different planes in view at the same time. The small portion with the cells represented as "pearls" or white dots is above the correct surface-focus. Near-by on each side of that part are some cells in correct focus, but the magnification is far too small to exhibit their structure. And on the portion opposite the white-dotted part the focus is below the surface and at about that of the inner cell-membrane, so that the cells appear like deep pits.

Most microscopists, when they see a diatom with its outline and markings all beautifully and sharply defined in what is termed a "crisp" manner, believe they are looking at its real structure and that it is in accurate focus. But usually this is not the case and only diffraction images and not the actual surface of the diatom is being seen, because these diffraction images can so easily be sharply and cleanly focussed, while the actual surface, at least of the cell-membranes, is usually distinctly difficult to focus, so that the shadow has often become accepted for the substance.

The "white-dot" focus is often a favourite with microscopists, but although the cells may appear sharply in focus, as, for example, in fig. 7 on pl. 4 (*A. sendaicus*), yet no structure can be detected upon them at that focus, however much they are magnified; the true focus is slightly below the one at which that photograph was made. And concerning the different appearances assumed by the same specimen as seen at different foci, and also when a small cone of light is used by closing the diaphragm, instead of a large one, see notes under *A. ornatus*, var. *dispar*, pl. 4, figs. 1–3, and *A. clarus*, pl. 6, fig. 2, which photographs were expressly made for me by Mr. Ellis, and I use them to show these points. If a larger cone of light had been used all these figures would have been whiter in appearance.

Many years ago I discovered that by a slight manipulation of the illumination it is quite easy to exhibit an *Arachnoidiscus* so that its cells appear to be either convex or concave at will, without altering any of the focal adjustments. And also, it is easily possible to exhibit it under a Wenham binocular so that the cells, when viewed separately down each tube, appear to be convex as seen down one tube and concave as seen down the other tube! Both views appear equally correct as to focus, but obviously both cannot be right, and therefore caused me to doubt if either was correct. And as at about this time, when talking about diatoms and their structure to a competent microscopist, I was told, "You can see all sorts of things on a diatom, some of them that are not there at all, but are merely ghosts," I have since spent a great deal of time in trying to find out which is the false and which the real view of the structure of a diatom, and here give details of my method of investigation for the benefit of beginners.

The correct focus and view of the structure of an *Arachnoidiscus* or other diatom under high powers is obtained only when the light is accurately centred and the membranes of the cells are distinctly seen slightly below the surface level of their bounding walls, like panes of glass in a window-sash. At this focus or at a very slight adjustment of it, if the lens is good enough and the magnification sufficient (some 2,000–5,000 diameters being required), the dotted structure of the membrane (differing in different species) will become evident if the manipulation is correct, for it is the latter which is the important factor.

To obtain this correct view of diatom structure the first thing to do is to obtain axial (i.e., central) light from the substage condenser through the objective used and the eyepiece. This cannot be done by merely moving the mirror about, but must be accomplished by a combined adjustment of the substage condenser and the mirror. Where the condenser is merely pushed into a sheath and has no adjusting screws, if the centring of the condenser does not correspond with that of the lens, as often happens, nothing can be done to improve the centring. But where centring screws exist one of the following methods should be tried. Of the different types of condenser in use probably the Abbe type gives the beginner most trouble to find out when it is properly centred. The following method, however, is an easy one, and is applicable to other types of condenser than the Abbe. Use a 1/6th objective and focus it upon a diatom or some transparent object, making the light as central as possible by means of the mirror, and rack the substage condenser up and down (but do not alter the focus of the objective) until an image of the lamp-flame or other source of light is in focus at the same time that the object is in focus. Then, without altering these adjustments, insert a central stop in the carrier and open the diaphragm wide. Now remove the eyepiece and upon looking down the tube the central stop should be seen surrounded by a ring of light; then, while looking down the tube, gradually close the diaphragm, and if it closes upon the central stop quite equally all round the condenser is properly centred ; but if (as usually happens) one part of the ring of light is obscured or eclipsed while the remainder of the ring remains bright, then the condenser is not exactly centred, but must be made so by means of the centring screws. During this process the mirror also will need several fresh adjustments, until at last a perfect and very slender ring, continuous or broken up into dots, is seen all round the central stop when the diaphragm is almost closed upon it. The light should now be nearly or quite central. To complete the process replace the eyepiece, remove the central stop and close the diaphragm, then, upon looking through the instrument, if the spot of light is not quite central make it so by moving the mirror, but do not alter any other adjustments. By these means axial or central light will have been obtained.

For those condensers that are not of the Abbe type the following method is also effective. Use any objective that is convenient, focus light from the substage condenser upon some small or transparent object and get it properly in focus, then close the diaphragm and rack the substage condenser down until the image of the small hole in the diaphragm is clearly in focus. If this hole does not appear to be central, it must be made so by means of the centring screws. When it appears quite central, then rack up the substage and move the mirror about until the image of the lamp-flame is also central and does not shift its position when the substage is racked up or down. If the light is seen to move slightly, the condenser must be slightly altered by the centring screws and the mirror slightly moved until no movement of the light is seen when the condenser is racked up or down. All adjustments will then be correct, and the whole process is very quickly accomplished when once understood. But it must be remembered that when an objective for which the light has been properly centred is changed for another, and it is desired to make careful observations with the fresh lens, the light must be recentred for that lens in the same way, because no two objectives are centred exactly alike, and perfect results are not obtainable with inaccurate lighting.

Also it should be understood that if a lamp is used as the illuminant, it is better to use the edge rather than the flat side of the flame; and if an incandescent gas-mantle is used it should be as seen through a clear (not frosted, coloured or engraved) glass globe. It is this latter illuminant that I generally use—that is, an inverted gas-mantle used to light the room—at about four or five feet from the mirror, and on one side of the instrument for convenience, and I find it suffices to resolve with axial light both *Amphipleura pellucida* and *Nitzschia singalensis* not merely into transverse lines, but more or less evidently into their component cells. To achieve this and other difficult resolutions of fine structure it is assumed that every microscopist is aware that the tube length for which the lens is corrected must be used, and also that it is necessary to use a screen of blue-green glass in the substage carrier or between the light and mirror to obtain perfect results, the green screen making a very great difference in the distinctness with which the structure is seen.

Having properly centred the light, care must be taken to focus the image of the flame or mantle upon the object, so that both the object and flame image are in focus at the same time. This is termed "critical illumination," and for detecting very minute structure is the very best that can be obtained. If a gas-mantle is used the condenser must be focussed just so that the meshes are invisible, but only just short of that point. When all appears correct, remove the eyepiece and look down the tube; if the lens appears full of light without any dark patches, all is correct, but if dark patches are evident, very slightly alter the focus of the substage condenser upwards or downwards until the dark patches just disappear and the lens is full of light. This is most important on all occasions, as those dark patches are excluding useful light that is needed to make a perfect image. As much light should be used by regulating with the diaphragm as the lens will permit without obliterating detail. For if the diaphragm is closed too much, so that the edges of the main structure become darker, the finer details, such as the faint dots upon the cell-membranes, become invisible.

To perceive the dots upon the cell-membrane of *A. Ehrenbergii*, I advise specimens from California should be tried, as I have found them easier to resolve on Californian than on Port Townsend (the type locality) specimens. On allied species, such as *A. sendaicus*, *A. oamaruensis* and *A. deficiens*, they can be also seen equally well. Although giving a better image, an apochromatic lens is not a necessity, as an achromatic one will reveal the structure quite satisfactorily. I use a Reichert achromatic 1/12th (really a 1/15th) oil-immersion lens of N.A. 1.27, in conjunction with a ×37 ocular, giving, on a 10-inch tube, 5,500 diameters magnification. The dots, however, can be seen with a ×18 ocular on some specimens at 2,700 diameters, even when a dry chromatic Abbe condenser of Watson make is used, although better when an achromatic oil-immersion condenser is used. I have also another make of Abbe condenser, but find that it will not serve to resolve these dots, so that resolution depends somewhat upon the quality of the condenser is evident. Having got the light accurately centred and a blue-green glass light-filter placed in the carrier of the condenser, and using the tube length for which the 1/12th lens is corrected, focus it upon the whitish and often lobed design that these diatoms often exhibit at a certain focus, but which is a mere structural diffraction image. When this is seen, *very* slowly focus downwards and the design will lose its distinctness, become reduced to a misty whitish patch and when the correct focus is obtained will be of a leaden or pallid colour and seen to be resolved into densely crowded pallid dots enmeshed in a very fine network of darker appearance, covering the membrane (see pl. 2, fig. 7), which will be seen to be slightly below the surface level of the shell. This delicate structure is easily overlooked ; it may be seen perhaps at the first attempt or perhaps not until many trials have been made to detect it, because of the difficulty in correctly focussing it and properly grading the light, for the membrane is probably not more than 1/200,000th of an inch thick, so that very exact focussing is necessary. If the cells appear bead-like the dots cannot be seen, as the bead-like appearance is an effect of incorrect lighting.

Those who have never seen these dots upon an *Arachnoidiscus* and expect to see them as clearly and as easily as those upon *Triceratium favus* and allies will be greatly disappointed, because they are *very much fainter*, far more minute, more densely crowded and very much more difficult to focus correctly. Anyone having the right apparatus who follows the above instructions may possibly succeed in detecting these dots at the first attempt and then fail for several times to see them again, as the making of them evident depends upon correct manipulation. And when using high powers it should be understood that a 1/12th objective at a magnification of 800–1,000 diameters will hold in focus a much greater thickness than one of these membranes and also that such magnification is usually not sufficient to render the dots upon the membranes distinct. As the magnification is increased by using eyepieces of greater power so the depth of focus held by the lens is lessened, the light becomes dimmer and the structure of the cell-membrane more evident, yet great care in focussing is necessary in order to detect the dots, which are usually very faint as they are merely thinner places in the membrane. Very slight alterations in closing or opening the diaphragm and in focussing the substage condenser sometimes result in making the structure more evident, and the amount of light should be modified so that it is not too bright or the structure becomes obliterated. Owing to the lessened depth of focus and to the curvature or unevenness of the surface of a diatom it often happens that only a very small part of that surface in the field of view is usually in accurate focus at one time, so that minute details are generally seen only on a small portion of the field of view, not all over it.

Development and Growth.

Very little appears to have been published or perhaps is known concerning the development and growth of any species of this genus. The only account of the development of the living organism I have been able to find is one by K. Yendo and K. Akatsuka in the Japanese *Botanical Magazine*, vol. 24, pp. 47–50, t. 3 (March, 1910), entitled "Auxospore formation of

Arachnoidiscus Ehrenbergii, Bail." And from this account and from the recent discovery made by Mr. and Mrs. E. J. Steer of Cape Town, South Africa, of the conjugating frustules and sporange cases of *A. ornatus*, of which they have very kindly sent me samples and allowed me to make use of them, the following seems to be the sequence of events.

Mr. and Mrs. Steer have found upon seaweed (*Suhria vittata*) which they collected about the year 1928 on the shore of Witzands Bay, a number of frustules of *A. ornatus* with multiple girdles (see pl. 1, fig. 5), i.e., frustules with the girdle very much broader than usual, each formed of a varying number of narrow bands, which have been added to the girdle of the upper valve (not to that of the lower valve, which remains unchanged) one at a time by the diatom, as required for expansion of growth. Upon these frustules and upon others received from Port Alfred with broadened girdles, Mr. and Mrs. Steer have noticed that a much smaller frustule of the same species is attached, usually upon the upper valve of the frustule, but sometimes at the side of it as represented on pl. 7, figs. 4 and 5. These small frustules are evidently the males of the species, the larger frustules being female. And this is evidence that the diatoms are able to crawl about. Most of the conjugating specimens observed had multiple girdles, but one specimen has been found by Mr. Steer in which the female frustule is apparently quite normal and without a multiple girdle. All Mr. Steer's material, however, is dead, so that it is quite impossible to tell what changes take place from the normal to the fully-developed multiple-girdled stage in such specimens. Yendo and Akatsuka, however, have studied the living frustule from the multiple-girdled stage, but make no mention of conjugating frustules. Their account is, briefly, that a frustule, fixed to some seaweed, becomes densely filled with chromoplasts and increases in size (i.e., thickness) by forming a multiple girdle (although they do not mention the structure of the girdle), until at length the upper valve and the whole of its girdle is burst off. As soon as the valves are separated the contents swell spherically and two polar regions are formed. This spherical mass is covered with a non-siliceous skin and is attached by a short transparent stalk to the inner surface of the lower valve of the old frustule, which remains attached to the seaweed (see pl. 7, figs. 2 and 3). This sphere gradually increases in size until it is immensely larger than the largest frustules, and becomes much compressed, the flattening being at right angles to the parent fixed valve to which it is attached, and the skin accommodates itself to the flattening and forms a capsule in which the contents undergo further changes. For the dense contents of the capsule first forms a radiating structure on each flattened or polar surface and becomes covered with a skin inside the non-siliceous capsule. Then one polar half of the mass within the capsule becomes more and more flattened, receding farther and farther from the wall of the capsule, while the other half remains unaltered, convex and close to the wall of the capsule. When the flattening of one half is complete, then the other half undergoes the same flattening process, the skin formed over the mass inside the capsule accommodating itself to the flattening, until at length a disk-like body is formed, a girdle is developed, the skin becomes siliceous with structure upon it similar to that of an ordinary frustule and thus forms a sporange. When the sporange is completely formed, the non-siliceous and brittle skin of the capsule cracks and the sporange is liberated (see pl. 7, figs. 2 and 3). At this stage the observations of Messrs. Yendo and Akatsuka end, and what becomes of the sporange and what changes it may undergo are at present unknown, and can only be discovered by cultivating the sporanges in well-aerated sea-water, and continually examining them. Mr. Steer informs me that sporange-capsules are not very plentiful among the material he obtained, which would seem to indicate that he obtained it at the time when the capsule-forming stage was at its commencement. And Mr. Steer also informs me that he has not found any more of such material at Witzands Bay nor anywhere else. Doubtless it is a seasonal phase that can only be found at a particular time of year and probably only in certain years under certain conditions, or it would have been discovered long ago.

This discovery by Mr. and Mrs. Steer that the male frustule is smaller than the female in *Arachnoidiscus*, seems similar to that of *Rhabdonema arcuatum*, described and figured by T. H. Buffham in the *Journal of the Quekett Club*, 1885, p. 131, t. 7–8, where also the male is smaller than the female, and it may also be the case in other genera. On pl. 7, fig. 1, is represented a photograph taken by Mr. Steer, of a group of *A. ornatus* arranged and mounted by Mrs. Steer, in which the small males are seen in the outer circle, the remainder being females of various sizes.

As these sporangial changes are seldom seen and still more seldom preserved and mounted in a natural condition, for boiling in acid destroys the non-siliceous capsule and contents of frustules, I copy here from *The Diatomaceæ of Philadelphia and Vicinity*, by C. S. Boyer, p. 11 (1916), a method of preserving them that may be found useful by those who are lucky enough to obtain living diatoms undergoing their interesting life-changes. Mr. Boyer's method is as follows. " By immersing in a saturated solution of picric acid, transferring to very dilute alcohol, which is gradually increased in strength, and then passing through oil of cloves, and finally to the mounting medium, excellent preparations may be made. By staining with gold chloride the nucleus is made apparent without further treatment."

The multiple girdle of the fertilised frustule is a very interesting structure to study. Slides have been sent to me on which Mrs. Steer has very skilfully mounted broken pieces of the girdle, some with the outer surface in contact with the cover-glass, and some with the broken ends in contact with the cover-glass. Broken pieces often reveal the true nature of structure better than the entire diatom, and it is so in this case. Viewed externally, the girdle, which is very transparent, is seen to be divided into or composed of a number of narrow encircling bands, by which it is evident the frustule increases in thickness by the addition of a fresh band to the girdle as required (see pl. 1, fig. 5). The bands are very clearly marked by a distinct line at their union, along which fracture takes place when broken, and each band has the following structures: (1) Occasionally some of the bands are destitute of markings, but usually the outer surface of each band is marked near one edge of it with a continuous ring of what appear to be minute black dots; sometimes there is only a single row of them, at others they are irregularly arranged and vary from one to four in the breadth of the ring (see pl. 1, fig. 6). Some of the largest of these dots, as seen at a magnification of 5,500 diameters, resolve into cells in the outer layer of the hoop, closed externally by a very thin membrane. (2) Scattered along the above-mentioned ring of dots at somewhat unequal distances are what at first sight look like highly refractive nodules or sometimes like short conical points, which, vertically, are arranged in spirals (see pl. 1, figs. 5 and 6), and it is by no means easy to detect their true structure, but after a prolonged examination they appear to me to be somewhat trumpet-shaped passages through the thicker part of each band, close to or at the suture joining two bands. The narrow end of the passage is at the outer surface, and sometimes seems in a slight depression, and is somewhat lunate in outline and closed externally by a very thin membrane. The broader or inner end terminates at the thin flap (presently to be described) that forms the inner layer of the girdle, and is slightly depressed there. This termination appears as a circular or elliptic spot, and where a detached flap can be found bearing one of these spots, by careful manipulation and at a magnification of 5,500 diameters, it can be seen that this spot consists of a very thin membrane densely covered with faint dots (pl. 1, fig. 8) like those on the cells of the valves of an *Arachnoidiscus*, but it is so extremely thin and so very transparent that the dots upon it are by no means easy to detect.

When the broken ends of the girdle are viewed and measured, it will be found that the girdle is roughly about 1/11,000th of an inch in thickness, and that each band in transverse section is shaped something like a comma, with the head of the comma somewhat square or with one of the angles rounded, and with the tail straight and exceedingly thin, so that each band or segment of the girdle consists of a solid ring with a thin flap or flange projecting from one edge of its inner surface, and in position the flap lies on and is probably cemented to the back of the band next to it, somewhat as represented in the diagrammatic sketch on pl. 1, fig. 7, the flap side (marked I.S.) being on the inner surface of the girdle. By the addition of band under band in this way the diatom is able to increase the breadth of the girdle and so raise the upper valve, which is always the smaller one, farther and farther from the lower valve.

From the examination of this structure it appears that the object of this complex structure is to enable the contents of the enlarging frustule to be well supplied with gaseous and fluid nourishment by means of the minute external and larger internal dotted membranes that close the minute external dots and the larger circular spots on the inner membranes formed by the flaps, and thus, while admitting gases and fluids, exclude organisms that might be harmful to the diatom.

As the cells of the first or central circle are different in form from the remainder of the cells of a valve, it is probable they serve some special purpose, and may be those by which the diatom is able to crawl about and fix itself.

As our knowledge of the reproduction of diatoms is very imperfect, I hope I may be pardoned for intruding here three illustrations (from photographs) of reproduction of other genera, especially as one illustrates a mode that has hitherto been entirely misunderstood. First, however, I would like to cast a stone at the word "auxospore" invented by Pfitzer in Hanstein, *Botanische Abhandlungen*, 1871, p. 62, for the product of conjugation by two frustules, which, from the time when Thwaites first observed and recorded the conjugation of diatoms in the *Annals and Mag. of Nat. Hist.*, 1847, pp. 9 and 343, had been correctly termed "Sporange." Pfitzer adopted and developed the view of J. D. Macdonald in *Annals and Mag. of Nat. Hist.*, January 1869, p. 1, pl. 3, that diatoms are unable to grow larger, and that by repeated division their frustules become smaller and smaller, until a smallest limit is reached, when frustules of this smallest size conjugated and produced a body that often grew to a much larger size than its parents, to which he gave the name "auxospore," because he conceived it to be the same as an adult frustule and that it repeated the division process. This, however, is evidently a mistake, for the so-called "auxospore" is either a spore from which a single frustule is developed, or a sporangium from which many frustules are developed, which grow and finally become adult. I therefore consider that the term "auxospore" and the fantastic fairy tale woven around it should both be abolished, for there is not a scrap of direct evidence to support the view. No "auxospore" has been recorded in a fossil state nor any record of measurements made of a dividing adult frustule or "auxospore" until it reached the minimum stage, to prove that it does reach that stage instead of growing larger and becoming adult. No record appears to have been made of what actually becomes of the sporangium, which seems to be covered with a thin siliceous shell; but the late Dr. Burton Brown once informed me that one he had under observation simply disappeared and a number of young frustules were observed; so, like the cyst in which the sporangium is formed, it probably is dissolved when the frustules are ready to emerge, possibly by some secretion they themselves exude; for, as diatoms are able to deposit silex to form their shells, they can probably dissolve it as required.

The illustration on pl. 1, fig. 4, is from a photograph sent to me by Mr. W. N. Ellis, of Appledore, of what I think may be *Amphora cymbifera*, and shows two examples where two frustules have encysted and produced two sporangia, which are evidently the result of conjugation. But figs. 2 and 3, on the same plate, represent another mode, which has also been figured by Smith, *Brit. Diat.*, vol. 2, pl. C, figs. I and II (fig. II is incorrect and seems drawn to fit the theory of auxospore formation), and by A. Schmidt, *Atlas*, t. 72, figs. 15–17, but which has been misinterpreted by authors. In *Le Diatomiste*, vol. 2, pl. 152 and 165, t. 10–13 (June 1895), Mr. J. Newton Combe gives a long account of the "Reproduction of Diatoms," in which he gives the name "megafrustule" to the sporangium. He adopts the view that diatoms do not grow larger, but decrease in size with each division, and all the encysted Cocconemas he figures he considers to be conjugating and producing "megafrustules." Also he advances the strange theory that the jelly-like structure in which the diatoms encyst themselves is not secreted by the diatom, but is produced by a Rhizopod. A theory that has no foundation. The figures I give are from photographs of mounted specimens of *Cymbella cistula* in my collection; the specimens have been stained with osmic acid, and the black spots and markings on the frustules indicate where the protoplasm or endochrome has condensed and taken the stain. Figs. 2, A and B, represent normal specimens with the denser or coloured parts of the protoplasm scattered all over the frustule, while fig. 2, C, represents a frustule that has just encysted itself, having first become transparent except for two dense masses of protoplasm with endochrome. The mucilaginous sheath enclosing it fits closely and is not seen in the photograph. Occasionally I have noticed that a totally different species of diatom has become encysted with the *Cymbella*, accidentally? On the straight side of the diatom is a very small frustule, also very transparent except for one small dense mass of protoplasm. This small frustule is not the product of division of an adult frustule to "the minimum size," but is a recently-born baby diatom! The baby emerges from its parent on the straight side at the centre of the girdle-suture as a minute, convex blob of protoplasm, which seems structureless as seen in water and is at first without a siliceous covering, but soon acquires one, and when about as big as the baby represented at fig. 2, C, very faint traces of markings become visible. I had mounted specimens of such newly-born babies and exhibited them on one occasion at the Quekett Club, but the slide has unfortunately been destroyed so that I am unable to represent the earliest stages. As the baby increases in size it crawls about its parent; another baby is added, and by degrees others, until at last the cyst contains usually seven frustules of different ages and size, as represented by fig. 3, where only five frustules are in focus, but there are two others in the cyst that are out of focus behind the larger specimens, but can (under the microscope) be seen through them.

In this view the gelatinous cyst or sheath can be seen in places. These seven frustules may include the product of one encysted frustule only, or of two frustules that encyst together, but in every case they are full-grown adult frustules that encyst, and I have not seen a trace of conjugation or sporangia in any of the numerous examples examined, and where one frustule only is at first in the cyst, there can be no conjugation within the cyst. The babies are born as above described, increase in size, and for a time each is of a different size from the others. As they grow larger and all attain to the same size they arrange themselves side by side so as to form a barrel-shaped mass within the cyst, and remain so for a time, during which the protoplasm loses its transparency, becomes denser, and the normal colouring of the mature diatom is assumed. Finally, when fully developed, the sheath dissolves or disappears and the seven (or possibly sometimes fewer or more) frustules are set free. From the above it will be understood that in cases of this kind there cannot be any sporange formed, and the statement that the contents of such cysts are "auxospores" or "megafrustules" is an entire misconception of the facts.

Although the above would seem to be an asexual mode of reproduction I am by no means sure that it is altogether what it seems. Smith, *Brit. Diat.*, vol. 2, pl. XV, states that in the same gathering in which he found the encysted reproductive specimens of *Cymbella* (*Cocconema*) *cistula*, he also found cysts enclosing minute frustules that had the outline and markings of *C. cistula*, and has figured them in the same volume, pl. C, figs. III, IV and V. And it happened that in the same gathering from which the specimens I represent by figs. 2 and 3 were obtained, I found exactly the same kind of minute frustules, of which one is represented on pl. 1 at fig. 2, D, and except in their size could not detect any specific difference between them and *C. cistula*. Is it possible that this small form is the male of the species? If so, then conjugation with the large form (*C. cistula*) may take place before the encysting stage occurs, for it certainly does not appear to take place after the frustule or frustules become encysted. This point requires careful investigation.

With reference to growth it seems to be a fashion among diatomists to deny that diatoms are capable of growth, because their shells are formed of silex, seemingly oblivious to the fact that teeth, ivory, horn and bone all can and do grow. It seems very absurd to conceive that diatoms out of all known living organisms should be the only group incapable of growth, especially as when looked for one can occasionally find clear evidence of their growth. In *Arachnoidiscus* specimens can occasionally be found in which increase in size is taking place or about to take place as shown on pl. 1, fig. 1 (*A. sendaicus*, N.E.Br.), where four of the secondary rays, A, B, C and D, are seen to have recently grown in to the centre and become primary rays, and others, as at E, are seen growing inwards; the tertiary rays are becoming secondary rays and new tertiary rays are forming. While this ingrowth of the rays is taking place it is evident the symmetry of the valve is maintained by the growth and increase in the number of the cells all over the shell where needed to make the rays equidistant again. The specimen of *A. ornatus*, var. *dispar*, on pl. 4, fig. 4, is another example with some rays growing inwards. The rays always grow inwards from margin to centre, and in some cases the cells in front of their inner ends may be seen to be dividing. It is in this manner that the species of this genus increase in size with age. As the process of growth probably takes place at night it is not very often that diatoms can be found clearly showing the act of growing or division, but I have seen several cases where this growth was evidently taking place. I have one specimen of a *Navicula* wrongly named "*N. lyra*," in which every cell throughout the shell is commencing to divide into two, so that if the process were completed that specimen would be nearly double its present length. This cell-division, however, cannot be seen unless a magnification of 4,000–5,000 diameters is used, so that it is probable from this cause other instances of cell-division have been overlooked, as few use such high magnification and consequently cannot see what is to be seen.

Explanation of Terms.

The terms used in the descriptions of the species and in the key have been explained under Structure, on p. 14, and are all illustrated on pl. 2, which is self-explanatory. It only remains to point out that, as described on p. 18, the *first circle* of cells on one valve often (perhaps always) differ in shape from those of the opposing valve of the same frustule. These different types are illustrated on pl. 3, where figs. 3 and 4 represent valves having the first circle of cells linear in shape, and figs. 2 and 5 valves with the first circle of cells cuneate or oval in shape. Where the cells are described as being in *pits*, it means that the surface membrane of the cell is sunk much deeper than usual below the surface of the solid part of the shell; such pits are represented in figures of *A. Grevilleanus* on pl. 6, fig. 8, and in those of *A. decorus* and *A. antarcticus* on pl. 6, figs. 3, 4 and 5.

With reference to the photographs reproduced in this book and indeed all photographs of diatoms, they can only portray the markings in black-and-white and do not represent the species exactly as seen by the eye under the microscope, and the photograph will vary in appearance according to the focus at which it is taken and the amount of light used to illuminate it. This is well exemplified by the figures of *A. ornatus*, var. *dispar*, on pl. 4, as I have already described on p. 19.

The figure of *A. giganteus* on pl. 6, fig. 6, by reason of the tilt of the specimen represents the valve as seen at different foci in one view, the part where the rays are white and the cells are pit-like is correctly in focus, and the part where the rays are black and the cells like white beads is out of focus.

The figure of *A. clarus* on pl. 6, fig. 2, is from a perfect trick photograph, but its reproduction does not show the same effect quite so well. The part where a few cells have a whitish bead-like appearance is very near the correct outer surface focus, and opposite where the cells seem like deep pits the focus is nearly or quite at the inner surface membrane of the cells. Now, if the photograph is looked at with a pocket lens at the part where the whitish cells are, the cells will probably appear to be shortly prominent above the surface, and the black rays slightly sunk; and if the opposite side of the valve is examined under the lens the cells will appear as deep pits; now if, while still looking through the lens, the lens is gradually brought round to where the whitish cells and black rays are, and looking chiefly at the outer portion, the cells will appear less and less deep, the rays prominent and the outer surface membrane of the cells appear sunk instead of elevated. This is really the correct focus view, but to my eyesight quickly changes back to the prominent cell appearance and sunken rays, also the proper sunken appearance is not always obtained at the first trial. I do not know the cause of the change. Fig. 6 on the same plate also shows the same peculiarity in a lesser degree. Pl. 6, fig. 1, represents another specimen of *A. clarus*, its white appearance being caused by a larger cone of light being used when photographed, for it really is a very clear diatom, and the closing of the diaphragm caused the dark appearance of fig. 2.

With reference to size I have not given actual measurements as I find them to be practically useless for determination of species, as they are not constant and overlap, an adult specimen of one species being no larger than a young one of an allied species. The cells, too, are often of nearly the same size in several species and also vary in the same species within limits, so that their size is often of no specific value. I have therefore used comparative measurements, which will probably be better understood by the general microscopist.

For the valve I use the three following terms :—

Small, from $\frac{2}{1000}$–$\frac{5}{1000}$ in. diameter, as in *A. Grevilleanus*.
Medium, ,, $\frac{5}{1000}$–$\frac{10}{1000}$ in. ,, ,, *A. Ehrenbergii*.
Large, over $\frac{10}{1000}$ in. ,, ,, *A. deficiens*.

For the cells I use the terms :—

Minute, when very small, as in *A. ornatus*.
Small, when as in *A. Ehrenbergii*.
Large, when as in *A. indicus*.

The above and other terms are illustrated on pl. 2.

The photographs of the valves are taken with a 1/10th objective at about 500–600 diameters' magnification, but figs.

7 and 8, on pl. 4, represent the structure as seen with a 1/12th objective. All have, however, been reduced to fit the plate and most are as seen at about 400 diameters.

ARACHNOIDISCUS, DEANE.

Frustule, like a shallow, flat pillbox in form. *Valve* circular, marked with numerous radiating ribs of different lengths, the longer being the *primary rays*; between each pair of primary rays is a shorter one, the *secondary ray*, and at the margin is often a very short line occasionally reduced to a large dot, more conspicuous than the small dots that occur all round the margin, forming the *tertiary ray* midway between the primary and secondary rays; in some species the tertiary ray is completely absent. On the inner surface of the valve the rays are flat (except just near the margin) in some species and very prominent and girder-like in others, and in the latter case are sometimes connected at the centre by a thin membrane, the *connecting membrane*, reminiscent of the web between a duck's toes. At the centre is a solid *central space*. Around the margin of the inner surface is a broad or narrow ledge or shelf-like membrane, the *marginal ledge*. In the substance of the shell are very numerous *cells* (the dots, beads or granules of other authors), closed on the outer and inner surfaces by very thin membranes, which under high magnification are seen to be dotted. The cells are arranged in more or less regular concentric circles with the rows between the rays unbroken and opposite at the rays, or in irregular or broken concentric circles with the rows between the rays alternating at the rays. The cells are separated concentrically and radially by solid spaces, forming the *concentric spaces* and *radial spaces*.

Species, twenty-six or more, all marine, of fixed (not free-swimming) habit, growing on seaweeds, mostly fossil, with a few (including those found in guano), living.

The presence of rays, the marginal ledge and the arrangement of the cells readily distinguish *Arachnoidiscus* from all other genera.

Distribution.

As the species of this genus are all marine and of fixed habit they are mostly confined to particular areas; one species only (*A. ornatus*), so far as known to the writer, being widely distributed. Yet, as we find in books that specimens from such widely different localities as California, New Zealand and Europe are considered to be one species or varieties of one species, it is evident that authors have neither given any attention to the study of the geographical distribution of these organisms nor properly examined and compared the specimens, or such extraordinarily incorrect determinations as are found in books would never have been made. For it will be found upon examination that the supposed variety nearly always has characters which, if small, are constant and proclaim it to be clearly distinct from the species to which it has been referred, apart from the difference of locality. Also we know nothing of the difference there may be in the fruiting (i.e., sporangial) stage of these plants, which among the higher plants usually furnishes important specific characters. The fossil deposits of California, W. Indies, Nicobar Isles, Hungary, Russia and New Zealand, each contain species that do not occur in the other deposits. And this local distribution exactly accords with the distribution of living plants at the present time.

The wide distribution of *A. ornatus*, Ehr. is, however, somewhat puzzling, and would seem to indicate that it has a different habit or different life history from other species. It is found living and fossil in all warm and suitable areas growing on seaweeds. And birds, or fish which in turn are eaten by birds, feed upon these seaweeds, for we find this diatom in their excrement (guano), which seems to indicate that it may be living within fifty miles of the guano locality. But why are not other species as widely distributed? It would, I believe, be impossible for birds to convey any species of this genus *alive* over the enormous distances that separate America from Asia, Africa and Southern Europe, as the living contents of the diatom would soon dry up and die. So it would appear that the wide dispersal of *A. ornatus* may be because this species grows upon floating species of seaweed, which are carried long distances by oceanic currents; while the other species grow only upon seaweeds or other organisms that are fixed or which grow at greater depths than the birds can reach, or are not eaten by them and so do not get distributed far from one area.

Only five or six of the known species are living, all the others are fossil, and *A. ornatus* is found both living and fossil. I do not know if either of the Nicobar species is living, but seem to understand both are fossil. And the fossil deposits indicate great changes in the past coast formation of regions where they occur.

The following is a list of the localities quoted and the species that are found in each locality :—

Adelie Land, Antarctic Region.—*antarcticus*, N.E.Br.

Barbados.—*clarus*, N.E.Br. ; *cognatus*, N.E.Br. ; *Grevilleanus*, Hardm ; *splendens*, N.E.Br.

Behring Sea.—*beringensis*, N.E.Br.

California.—*abnormis*, N.E.Br. ; *Adamsii*, N.E.Br. ; *decorus*, N.E.Br. ; *Ehrenbergii* var. *montereyanus*, A. Schm. ; *evanescens*, N.E.Br. ; *ornatus* var. *montereyanus*, A. Schm. ; *spissus*, N.E.Br.

Czecho-Slovakia and Hungary.—*hungaricus*, N.E.Br. ; *similis*, N.E.Br.

Hayti.—*clarus*, N.E.Br. ; *confusus*, N.E.Br. ; *Longii*, N.E.Br.

Italy.—*ornatus* var. *obscurus*, Forti.

Japan.—*sendaicus*, N.E.Br.

Kamtschatka.—*sendaicus*, N.E.Br.

Nancowry, Nicobar Isles.—*cibdelus*, N.E.Br. ; *indicus*, Ehr.

Oamaru, New Zealand.—*deficiens*, N.E.Br. ; *lepidus*, N.E.Br. ; *oamaruensis*, N.E.Br.

Russia.—*giganteus*, Pant. ; *ornatus* var. *dispar*, N.E.Br. ; *russicus* Pant.

Spain.—*ornatus* var. *obscurus* Forti.

W. Coast of N. America.—*Ehrenbergii*, Bailey.

Widely distributed.—*ornatus*, Ehr.

Without locality.—*evanescens*, var. *paulus*, N.E.Br. ; *major*, N.E.Br.

Key to the Species.

When naming by means of this key a 1/12th oil-immersion lens and transmitted light gives the best result, and has been used throughout for making it. The characters given are as seen on the outer surface of the valve, except as to the connecting membrane between the rays at the centre, and the marginal ledge, which are on the inner surface. For determining which surface is next the cover-glass see p. 14 and for explanation of terms used see p. 35 and pl. 2.

To use this key the two (there are rarely more) or all paragraphs bearing the same number should be read to determine which of the contrasted characters best fit the specimen, then pass to the next coupled paragraphs under the one found to agree, until a name is found that appears to agree with the specimen in the characters noted, when a comparison with the description and figures quoted under it should be made. Species that vary in certain characters are inserted at more than one place in the key.

1. Valve marked with a coarse, black or black-edged or rarely white network often resembling the web of the garden spider, in which the cells are enmeshed. To end of pars. 4.

2. Cells small or minute, subequal in size and arranged in groups in the meshes of the network.

3. Valve with transverse black lines between the rays on the whole or part of the central area and the marginal part with a coarse black network; cells in 2–3 rows in each group. Widely distributed. 1. *ornatus*.

3. Valve marked as above for typical *A. ornatus*, but thicker, less transparent, and the markings less clearly defined. Italy and Spain. 1. *ornatus* var. *obscurus*.

3. Valve nearly covered with a black network, with or without a few transverse straight lines between the rays; cells rather irregularly arranged. California. 1. *ornatus* var. *montereyanus*.

3. Valve with the black network confined to

the marginal part, without transverse straight lines between the rays ; cells not in regular rows between the dark meshes. California, Japan. hybrids of 1. *ornatus*.

3. Valve as seen at the correct focus entirely covered with an irregular white network enclosing the cells (often in groups) between the rays, without any transverse black lines or black network except when out of proper focus. Russia, at Kuznetsk. 1. *ornatus* var. *dispar*.

2. Cells or most of them large or very large and very transparent, very irregular in size and shape, each cell filling one of the meshes of the coarse network, which is often (perhaps always) black or white according to focus ; primary rays connected by a membrane at the centre on the inner surface ; transverse partitions between the rays and the irregular radial partitions often with tooth-like projections.

4. Valve very large ; central space moderately large ; marginal ledge broad, and nearly half as broad as the space between two primary rays at the margin. Locality unknown ; Gazelle expedition. 3. *major*.

4. Valve small or of medium size ; central space very small ; marginal ledge narrow and about $\frac{1}{5}$–$\frac{1}{4}$ as broad as the space between two primary rays at the margin. West Indies ; Hayti. 2. *Longii*.

1. Valve not marked (apart from the concentric and radial spaces) with a web-like or white network. To end of key.

5. Primary rays oblique or crooked ; cells all irregularly arranged, nowhere forming concentric rings, all separate. California. 20. *abnormis*.

5. Primary rays directed straight in from margin to centre, but sometimes themselves zigzag. To end of key.

6. Valve with a broad zone of cells much larger than the others at less than half-way between centre and margin; rays stout, white, with black-edged tips. Barbados. 14. *splendens.*
6. Valve without a zone of cells larger than the other cells on the valve. To end of key.
7. Primary rays black, or occasionally black or white according to focus, or rarely (in 15, *A. indicus*) white with black edges for most of their length, and with or without a slender, continuous or beaded or zigzag mid-line. To end of pars. 20.
8. Cells between the rays apparently very small and crowded in indefinite confusion. Hayti. 4. *confusus.*
8. Cells between the rays large to small, never very small nor minute, arranged in rows and separate or crowded or sometimes (in 25, *A. antarcticus*; 19, *A. decorus*, and 8, *A. sendaicus*) in groups of 2–4; the rows opposite at the rays and forming continuous circles, or alternating at the rays and forming broken circles, or sometimes very irregular. See also *A. ornatus* var. *dispar*, in which the very small cells are enmeshed in a white network.
9. Tertiary rays as seen on the outer surface reduced to slender and very short lines, mere dots, or indistinct or none; primary rays without a connecting membrane on the inner surface at the centre. To end of pars. 13.
10. Cells of central area to nearly one-third of the diameter of the valve in hexagonal pits and irregularly arranged in a mass of 4–6 series, and the rows between the rays alternating at

the rays, all sunk in pits. New Zealand, fossil. 13. *deficiens.*

10. Cells all in concentric circles with the rows usually opposite but occasionally alternate at the rays.

11. Marginal ledge broad, and $\frac{1}{3}$–$\frac{1}{2}$ as broad as the marginal space between two primary rays.

12. Primary rays 21 (or more ?); central space and the first and second concentric spaces forming a disk-like area from which the black rays radiate. Barbados, fossil. 6. *cognatus.*

12. Primary rays 24–44; central space and first and second concentric spaces not forming a disk-like area; cells often in pits. Hungary, fossil. 10. *hungaricus.*

11. Marginal ledge narrow and $\frac{1}{6}$–$\frac{1}{4}$ as broad as a marginal space between two primary rays, which penetrate to the third or second circle of cells, and are black or white with black edges for a part of all of their length; valve clear.

13. Primary rays 15–30, very slender; surface contour of valve seen binocularly with the marginal part slightly and gradually sloping to the edge. Nicobar Isles, fossil. 15. *indicus.*

13. Primary rays 13–20, rather slender; surface contour as seen binocularly with the marginal part nearly perpendicularly bent down to the edge. West Indies, fossil. 16. *clarus.*

9. Tertiary rays as seen from the outer surface of the valve present and conspicuous.

14. Connecting membrane of primary rays on inner surface absent.

15. Primary rays penetrating to only about half-way in to the centre, see 21. *evanescens* var. *paulus*.

15. Primary rays penetrating to three-quarters or farther in to the centre; cells not sunk in pits.

16. Primary rays conspicuously sinuous or zigzag; rows of cells mostly alternating at the rays; marginal ledge broad. Russia. 8. *russicus*.

16. Primary rays not zigzag; rows of cells mostly opposite at the rays; marginal ledge narrow.

17. Primary rays conspicuously black or black-edged only to the sixth circle of cells and with a very slender, wavy, clear mid-line. California. 12. *Adamsii*.

17. Primary rays slender, black, with or without a white beaded mid-line, and penetrating to the fourth, third, or second circle of cells. New Zealand. 9. *oamaruensis*.

14. Connecting membrane of primary rays on inner surface present and conspicuous; marginal ledge broad.

18. Cells contiguous in groups of 2–4 or crowded in rows and on the inner surface usually (but not always) seen as through window-like openings formed by the dilated

or winged edges of the concentric and radial spaces. Japan. 7. *sendaicus*.

18. Cells all separate and distinct, or, if crowded, without window-like openings to them on the inner surface of the valve, and arranged in more or less regular concentric circles with the rows opposite at the rays.

19. Cells crowded, rather large and sunk in pits; concentric spaces about $\frac{1}{4}$–$\frac{1}{3}$ as broad as the cells are long. California. 18. *spissus*.

19. Cells rather small, not crowded nor in pits; concentric spaces from half as broad to as broad as the cells are long; primary rays black or dusky.

20. Primary rays penetrating to the third or second (or in var. *montereyanus* to only the fourth) circle of cells; tertiary rays often extending across the marginal ledge. W. Coast of N. America. 5. *Ehrenbergii*.

20. Primary rays penetrating to only the fifth circle of cells; tertiary rays not extending across the marginal ledge. Hungary. 11. *similis*.

7. Primary rays white, with black tips and often black edges for a part or nearly all their length. To end of key.

21. Tertiary rays inconspicuous, reduced to to mere dots or none. See also *A. antarcticus* in which they are sometimes very faint.

22. Rays stout, with black tips and

interrupted black edges along the outer part; secondary rays represented as connected with the primary by a black-edged membrane or plate towards the margin. Nicobar Isles. 23. *cibdelus.*

22. Rays slender; rows of cells usually opposite at the rays.

23. Marginal ledge $\frac{1}{3}$–$\frac{1}{2}$ as broad as the marginal space between two primary rays, the black edges of the rays usually vanishing between the eighth and third circles of cells, which are small and often sunk in pits. Hungary. 10. *hungaricus.*

23. Marginal ledge $\frac{1}{5}$–$\frac{1}{4}$ as broad as the marginal space between two primary rays; cells moderately large.

24. Primary rays very slender and black-edged all along, or entirely black; surface contour as seen binocularly with the marginal part sloping gradually to the edge. Nicobar Isles, fossil. 15. *indicus.*

24. Primary rays rather slender and black-edged for $\frac{1}{4}$–$\frac{1}{3}$ of their length, or entirely black; surface contour, as seen binocularly, with the marginal part nearly perpendicularly bent down to the edge. Barbados, fossil. 16. *clarus.*

21. Tertiary rays usually conspicuous as either short lines extending half-way or all across the marginal ledge or at least as dots that are much larger than those on the extreme margin. To end of key.

25. Many of the cells in groups of 2–3 and sunk in pits, which are sometimes

faint, and the rows usually opposite at the rays.

26. Valve circular or oval, with the central area to about the fourth circle of cells with very broad concentric spaces forming a sort of disk in which the groups of cells are immersed, and from its outer margin the rays are black-edged. Antarctic region. 25. *antarcticus.*

26. Valve circular, without a central disk-like area (apart from the central space), and all the concentric spaces of equal width and narrow ; primary rays clearly distinct in to the third or second circle of cells and entirely white or black-edged for $\frac{1}{3}$–$\frac{1}{2}$ of their length. California. 19. *decorus.*

25. Cells all separate.

27. Cells lobed and with a conspicuous black dot in each corner, not seen in any other species ; rays very stout, black-edged at the tips only. Behring Sea. 24. *beringensis.*

27. Cells entire or lobed, but without black dots.

28. Rows of cells between the rays, mostly opposite (or here and there alternating) at the rays ; central space of moderate size or large.

29. Primary rays with black edges for $\frac{1}{3}$–$\frac{1}{2}$ of their length on outer surface, and on the inner surface sometimes for all their length ; radial spaces between the cells usually narrower than the cells are broad. California. 19. *decorus.*

29. Primary rays black-edged for $\frac{1}{6}$–$\frac{1}{3}$ of their length ; radial spaces between the cells from nearly as broad to twice as broad as the cells are broad. 21. *evanescens.*

28. Rows of cells between the rays alternating at the rays.

30. Cells small, crowded and in pits ; valve small ; central space in valve with the cells of the first circle linear and perhaps also in the opposing valve very small and sometimes nearly obsolete ; primary rays black or black-edged at the tips only. Barbados. 26. *Grevilleanus.*

30. Cells of moderate or large size, not crowded ; central space always of moderate size or large.

31. Valve large or of medium size ; primary rays black-edged for $\frac{1}{5}$–$\frac{1}{4}$ of the way in to the centre and not or scarcely zigzag at the tips ; cells all without faint hexagonal outlines. Russia. 17. *giganteus.*

31. Valve small ; primary rays black-edged and very distinctly zigzag to about one-third of the way in to the centre ; cells in the central part of the valve encircled by faint hexagonal outlines as seen at the correct focus, indicating pits. New Zealand. 22. *lepidus.*

1. **A. ornatus, Ehrenb.**, Pl. 3, fig. 2–5. Valve of medium to large size. Primary rays 11–36, slender, black or white with black edges, penetrating to the second circle of cells in the valve having the cells of the first circle linear, and in the opposing valve having the first circle of cells wedge-shaped passing as clear lines to the central space; on the inner surface they are prominent and girder-like and connected by a membrane at the centre; secondary rays 1/6th–1/3rd as long as the primary; tertiary rays as long as or shorter than the marginal ledge is broad; between the rays the whole surface is covered with several irregular series of subparallel, slender, black or black-edged lines that towards the margin pass into a coarse network, something like the web of the garden spider. Central space of moderate size or large, sometimes dotted. Cells of the first circle larger than the others linear or wedge-shaped on opposing valves; cells between the rays very small or minute, and crowded in groups enclosed in the meshes of the network. Marginal ledge variable, but usually broad.

Viewed binocularly the outer surface has a somewhat bun-like curvature and the central space often slightly raised, with the areas between the rays in slightly convex ridges. The first circle of cells is slightly depressed around the central space, which appears as if standing in the centre of a sort of openwork basket, of which the rim is formed by the outer margins of the second circle of cells, forming a pretty structure. *A. ornatus*, Ehr. in Bericht Akad. Berlin, 1849, p. 64; Pritchard, Infus. ed., 1861, p. 842, t. 15, f. 18–21; Schmidt, Atl., t. 73, f. 4–6; De Toni, Syllog. Alg., v. 3, p. 1311; Janisch in Abhandl. Schlesisch. f. Vaterl. Cult. Breslau, 1861, p. 159, t. 1, f. 3, and 1862, p. 28, t. 1B, f. 5 (very poor), and t. 2A, f. 3 and 11; Schütt in Engl. and Prantl, Pflanzenfam, v. 1, pt. 1B, p. 69, f. 95; Okamura in Rep. Imp. Fisheries Instit. (Japan), 1911, p. 2, t. 8, f. 6 (very poor); Saxton in Engl. Mechanic, 1919, v. 110, p. 198. *A. ornatus* var. *marylandica*, Welsh in Amer. Micr. Soc., 1915, p. 291, t. 16, f. 2. *A. japonicus*, Pritchard, Infus. ed., 1852, p. 319, t. 24, f. 18–21; Deane in Quarterly Journ. Micr. Scien. v. 6, p. 188 (1858); Beck, Treat. Micr., 1865, p. 13. *A. nicobaricus*, *Ehrenb.*, Microgeol. p. 165,

t. 36 (not t. 30 as often quoted), f. 35 (1854); and Micr. Dict., ed. 1875, p. 67, t. 42, f. 4. *A. formosus*, Arnott (*Hemiptychus formosus*, Ehr. ex. Arnott) in Quarterly Journ. Micr. Science, v. 6, p. 162 (1858), name only. *A. Ehrenbergii* var. *californica*, Schmidt, Atl., t. 73, f. 1; Wolle, Dict. of N. Amer., t. 91, f. 3 (poor). *A. Mannii*, Hanna and Grant in Bull. Amer. Assoc. Petrol. Geol., 1925, t. 5, f. 2; in Proc. Calif. Acad. Scien., 1926, p. 125, t. 12, f. 7–9; and 1932, p. 174, t. 5, f. 1; and in Journ. Paleont., 1927, p. 109, t. 17, f. 5, excluding synonyms. *A. sp.*, Shadbolt, in Trans. Micr. Soc. Lond., 1852, v. 3, p. 40, t. 11, f. 1–5. *Hemiptychus ornatus*, *Ehr*. in Bericht Akad. Berlin, 1848, p. 7, Ann. and Mag. Nat. Hist., 1848, v. 1, p. 392; Mann in Contrib. U.S. Nation. Herb., v. 10, p. 267 (1907).

This is the most widely distributed species of the genus and the only one that is so, all others being more or less local. *A. ornatus* occurs in the seas of Japan, Nicobar Isles, Mauritius, Rodrigues, New Zealand, South Africa, Ichaboe, Patagonia, Peru, California, etc., living and fossil.

Figs. 2 and 3 represent the typical form of the species from Japan. Figs. 4 and 5 represent a form from Mauritius with differently arranged cells, but intermediate forms occur. Figs. 3 and 4 represent valves with the cells of the first circle linear, and 2 and 5 opposing valves with them cuneate or oval.

Var. **montereyanus** (by error *montereiana*), **Schmidt.** A form with the greater part of the surface covered with an irregular network of dark lines, without or with only a few regularly arranged, concentric, transverse lines between the rays near the centre. Cells more irregularly arranged and not so crowded as in the typical form. *A. ornatus* var. *montereiana*, Schmidt, Atl., t. 73, f. 8–9 (not 7), see note below; Wolle, Diat. of N. Amer., t. 91, f. 9 only.

California: at Monterey, fossil.

I restrict this variety to the form represented by the two figures in Schmidt's Atlas (copied by Wolle) above quoted.

The form represented in Schmidt's Atlas, t. 73, f. 7, and in Wolle, Diat. N. Amer., t. 91, f. 8, from Monterey, California, in which the dark network is confined to the outer zone and scarcely extends half-way from the margin to the centre, without either concentric or irregular dark transverse lines on the rest of the valve and with more scattered cells, is a view of the inner surface of the valve, probably with the network or transverse lines out of focus, but whether of the typical form or of var. *montereyanus* or a distinct variety, cannot be determined without examination of the specimen from which the drawing was made. I have not seen one like it.

Hanna and Grant consider *A. Mannii* to be the same as the variety *montereyanus*, but it is not that form as I understand it, and I do not see how it differs from typical *A. ornatus*.

Var. **obscurus** (by error *obscura*), **Forti**. A form having all the general characters of the type, but the shell is thicker, less transparent, the rays and the transverse lines between them are stouter and less clearly defined, the tertiary rays are obscure or sometimes imperceptible on the outer surface, and the cells less distinct, and according to the figures the whole of the markings have a more or less blurred appearance. *A. ornatus* var. *obscurus* (*obscura*), Forti, in Atti del Itsit. Veneto di Scien., v. 72, pt. 2, p. 1580 (and reprint p. 46), t. 4, f. 3–8, and t. 5, f. 5 (1913), and in Nuova Notarisia, 1914, v. 25, p. 107, t. 4, f. 3–8, and t. 5, f. 5.

Italy: near Marmorito; and Spain: near Montemayer, fossil.

I have not seen Italian specimens of this form, but the Spanish specimens do not present such a blurred appearance as the figures above quoted represent.

Var. **dispar, N.E.Br.** Pl. 4, figs. 1–4. Valve of medium size entirely covered with an irregular, fine white network enclosing the small cells in its meshes, without black transverse lines or black network as seen at the correct focus (fig. 1, which would have been whiter if a larger cone of light had been used), otherwise as in the type. Figs. 2 and 3 represent the same valve as fig. 1, as seen at different foci. Fig. 4 is a different valve of the same variety.

Russia: at Kuznetsk, fossil.

For *A. ornatus*, Van Heurck, Treatise on Diat., p. 506, fig. 255 (not of Ehrenberg), see *A. Ehrenbergii*, Bail.

A. ornatus is the species upon which the genus *Arachnoidiscus* was founded as detailed on p. 11 under the general history. It is interesting to note that it appears to have been as widely spread in Miocene times as now, for it occurs in a fossil state in such widely separated areas as New Zealand, Europe, and the Atlantic and Pacific sides of N. America. As it is the only known species that is widely dispersed there must be some particular cause for this fact, and I suggest the explanation given on p. 38. An interesting account of its discovery in the Maryland deposit in Eastern N. America is given in the Amer. Microscop. Soc., 1915, p. 290, t. 16, fig. 2, by Major B. C. Welsh, who first found it in some diatomaceous earth which was uncovered when excavating for a State road and sent to him by a friend in Maryland. He states: "I have since visited the locality and made careful examination of the bank from which it came. The *Arachnoidiscus* apparently occurs only in the topmost part of the deposit, and a few feet underneath the level at which it occurs most plentifully it disappears entirely when we reach the typical rich bed of diatomaceous earth. Another outcrop about 500 yards away also shows it; but elsewhere I have been entirely unable to find it. The deposit, a part of the Maryland Miocene, of which the Richmond beds form part, is at a point known as Birds Hill, on the State Road about nine miles south of Anapolis. At this place it is about one hundred feet above sea-level, and is the highest point I know of at which this earth shows. The deposit is only a few feet above sea-level at Ferry Landing, opposite Nottingham and at the Calvert Cliffs on the Chesapeake Bay, both these latter places being about twenty-five miles south of Birds Hill." Major Welsh calls this "*A. ornatus* var. *marylandica*," but the specimens I have of it from the original gathering, sent to me by Mr. H. C. Wheeler, possess no character by which it can be distinguished from specimens of *A. ornatus* living now.

Ehrenberg states that his specimen of *Hemiptychus ornatus* was mounted by Topping, from Patagonian guano, and I have seen an old slide of this species mounted by Topping, which in all probability formed one of the same batch of slides as that sent to Ehrenberg. The slide is unnamed by Topping, but has been named "*A. japonicus*" by some other person, doubtless from Pritchard's figure of it under that name.

2. **A. Longii, N.E.Br.** Pl. 3, fig. 1. Valve of small or medium size, covered with a coarse and very irregular network, black or white according to focus. Primary rays 12–15, penetrating to the first circle of cells, slender, but nodose or thickened where the cross-partitions unite with them, wide apart at the margin, and connected by a membrane on the inner surface at the centre; secondary rays penetrating one quarter to half-way in to the centre; tertiary rays reduced to mere dots or evanescent. Between the rays the very irregular network is formed centrally of nearly straight cross partitions and irregular radial partitions, both of which are toothed in places, and toward the margin passing into an irregular network. Central space very small, sometimes evanescent, surrounded on some valves by 6–8 large and broadly cuneate cells outside of which the network between the rays commences, or on other valves there is a circle of cuneate cells between the rays, outside of which is a circle of smaller circular or two-lobed cells, and beyond them the network extends to the margin. Cells between the rays very irregular in size and shape, some of them unusually large, very transparent, and the membranes not or scarcely evident by transmitted light, but can be easily seen under dark-ground illumination. Concentric and radial spaces formed of the above-described irregular network. Marginal ledge narrow, about $\frac{1}{5}$–$\frac{1}{4}$ as broad as a marginal space between two primary rays.

Viewed binocularly the outer surface is like an inverted cake-tin in form and slightly depressed from the vertical margin to the centre, with the central cells raised into a cone and the areas between the rays slightly convex.—*A. ornatus*, Truan and Witt, Diat. Jérémie, p. 11, t. 2, fig. 15.

West Indies: Hayti, at Jérémie, fossil.

Described from a specimen in the collection of Mr. J. A. Long, and from others on a slide in the collection of Mr. F. Adams, labelled "Type platte III, Alfredo Truan."

This appears to me a very interesting diatom, especially when viewed under dark-ground illumination. The photographic representation of it (pl. 3, fig. 1), made from Mr. Long's specimen, gives no idea of the beauty of its real appearance.

It differs from *A. ornatus*, Ehrenb., by its smaller size, thinner substance, very much smaller central space, very much larger and more irregularly shaped cells and narrow marginal ledge.

3. **A. major, N.E.Br.** Valve very large. Primary rays represented as penetrating to the second circle of cells, not very slender, black. Secondary and tertiary rays also black. Transverse partitions between the rays rather broad, irregular and often toothed. Central space moderately large, surrounded by a circle of large linear cells, outside of which is a circle of round cells. No other cells are represented, but I suspect the extremely fine radial or irregular partitions dividing the large clear areas between the rays into large irregular cells were overlooked and are not represented by the artist. Marginal ledge nearly half as broad as a marginal space between two primary rays.—*A. ornatus* var. A. Schmidt, Atl., t. 73, p. 10.

Locality not stated; Gazelle Expedition.

I have not seen a specimen of this and describe from the figure quoted, which represents it as one of the giants of the genus. It is so distinct from *A. ornatus*, Ehrenb., that it is difficult to understand how it could possibly have been supposed to be a variety of that species, which is characterised by its minute cells.

A. major is closely allied to *A. Longii*, N.E.Br., but conspicuously differs by its very large size, the much larger central space and very much broader marginal ledge, and if they could be compared probably other distinctions would be observable.

4. **A. confusus, N.E.Br.** Valve large. Primary rays represented as 38 and rather close together, penetrating to the second circle of cells, slender, black, with a mid-line of white dots, and there is some indication in the figure that they may be connected by a membrane at the centre on the inner surface, but this is not certain; secondary rays about one-fifth as long as the primary and not much exceeding the width of the marginal ledge except where increase of size is taking place and new primary rays are being formed; tertiary rays dot-like. Central space large. First circle of 39 linear cells, rather crowded;

second circle of 39 small and crowded circular cells; all the cells outside of this second circle are represented as very small or minute and crowded in intricate and indistinct confusion, not in regular or irregular concentric circles. Marginal ledge broad, and half or more than half as broad as a marginal space between two primary rays.—*A. Ehrenbergii* var. *californica*, Truan and Witt, Diat. Jérémie, p. 11, not of A. Schmidt, and *A. Ehrenbergii*, Truan and Witt, on t. 2, f. 8 of the same work, not of Bailey.

West Indies: Hayti; Jérémie deposit, fossil.

I have not seen a specimen of this species, but according to the figure it is quite distinct from *A. Ehrenbergii*, Bail., in its structure, as well as in its very different locality.

5. **A. Ehrenbergii, Bailey.** Pl. 4, fig. 5. Valve of medium to large size. Primary rays 18–34, penetrating to the third circle of cells, slender, black, and on the inner surface prominent and girder-like, and connected by a broad membrane at the centre; secondary rays with the black part $\frac{1}{6}$–$\frac{1}{3}$ as long as the primary, but traceable as clear lines to about half-way to the centre; tertiary rays very distinct and about as long as the width of the marginal ledge. Central space of moderate size. Cells in about 16–32 closely-placed concentric circles, with the rows between the rays mostly opposite but occasionally alternate at the rays; those of the first circle linear or cuneate on the opposing valves, the remainder small or of moderate size, separate and distinct except in what I believe to be hybrid forms (see note below), usually longer than broad, lobed or entire. Concentric spaces from half as broad to as broad as the cells are long; radial spaces much narrower. Marginal ledge from half as broad to nearly as broad as a marginal space between two primary rays.

Viewed binocularly the surface is flattish or slightly raised at the centre, with the areas between the rays slightly convex, and with a precipitous slope to the margin.—*A. Ehrenbergii*, Bailey ex. Ehrenberg in Berlin Akad., 1849, p. 64; and Bailey in Wilkes U.S. Explor. Exped., v. 17, p. 174, Algæ, t. 9, f. 9–10 (1862); Microgr. Dict., ed. 1, p. 59, t. 12, f. 12–13; Smith, Brit.

Diat., v. 1, p. 26, t. 31, f. 256; Nelson and Karop in Journ. Quek. Micr. Club, 1888, p. 42, t. 4, f. 4, cell-structure only; De Toni, Sylloge, Alg., v. 3, p. 1311; Boyer in Proc. Acad. Nat. Scien. Philadelph., 1927, p. 68; and Janisch in Abhandl. Schlesisch Gesellsch. Vaterl. Cult., 1861, p. 158; and 1862, t. 2A, f. 3 and 11. *A. Ehrenbergii* var. *californicus* (*californica*), A. Schmidt, Atl., t. 68, f. 3–4; Wolle, Diat. N. Amer., t. 91, f. 4; Laporte and Lefebure, Diat. Rares et Cur., v. 1, t. 2, f. 11.

West Coast of N. America from Port Townsend (Puget Sound), the type locality, southwards to California.

A mere form of the above found living on the coast of California, that from growing crowded together from infancy has, by mutual pressure, assumed a shape that is "bluntly cuneiform, with sides compressed and two sets of short rays" has been described by Sarah P. Monks in Proc. Acad. Nat. Sciences, 1920, p. 207, under the name of *A. Ehrenbergii* var. *cuneatus*. But, as indicated above, such forms are mere abnormal developments caused by mutual pressure, and not real varieties.

Boyer, at the place above quoted, states that the type locality for *A. Ehrenbergii* is Japan, but this is an error, for Bailey in Wilkes Expl. Exped., v. 17, p. 174, states it is from Puget Sound, and on p. 176 that it is also found at San Francisco. The figure in this book (pl. 4, fig. 5) is from Port Townsend in Puget Sound, the type locality.

Var. **montereyanus (montereyana), A. Schmidt.** Primary rays penetrating to the third circle of cells, otherwise as in the type.—A. Schmidt, Atl., t. 68, f. 2; Wolle, Diat. of N. Amer., t. 91, f. 2; De Toni, Sylloge Alg., v. 3, p. 1312. And probably also belong here *A. Ehrenbergii* var. O'Donoghue in English Mechanic, Dec. 10, 1915.

California, at Monterey.

In the typical form and in the above variety the cells are all more or less separate and distinct or two or three somewhat grouped together, but in some other forms seen they are much smaller and more or less contiguous into irregular groups. I believe these to have been influenced by hybridisation with *A. ornatus*.

6. **A. cognatus, N.E.Br.** Pl. 5, fig. 7. Valve of medium size. Primary rays of the only specimen seen 21, penetrating to the third circle of cells, slender, black, and on the inner surface prominent and girder-like, narrowly winged on their free edges and without a distinct connecting membrane but merging into the first two or three concentric spaces of the centre ; secondary rays (except when growing) mostly about $\frac{1}{3}$ as long as the primary ; tertiary rays often indistinct or scarcely detectable on the outer surface, but on the inner surface are, in some places, seen extending about half-way across the marginal ledge. Central space moderately large. First circle of cells linear, surrounded by a circle of rather small round cells ; the cells between the rays in about twenty or more circles, with the rows opposite at the rays, crowded so that near the margins there are 10–12 in a row between the primary rays, roundish to oblong, entire. Concentric spaces narrower than the cells are long ; radial, very narrow. Marginal ledge broad, about $\frac{1}{3}$ as broad as a marginal space between two primary rays.

Viewed binocularly the outer surface is flattish, with the central part raised, and the areas between the rays slightly convex, and with a precipitous slope to the margin.

West Indies : Barbados ; at Newcastle, fossil.

This is closely allied to *A. Ehrenbergii*, Bail., and has (on some slides) been mistaken for that species, but whether considered as a distinct species, as I have done, or as a variety of *A. Ehrenbergii*, it distinctly differs from the latter by the absence of or less evident tertiary rays, which are very conspicuous in *A. Ehrenbergii*; by the absence of the membrane connecting the rays at the centre of the inner surface, seen in *A. Ehrenbergii* at the proper focus, at about the fifth circle of cells; the entire, larger, and more crowded and differently arranged cells between the rays ; the stouter linear cells of the first circle and the very different locality. The figure represents the inner surface of the valve, with the marginal ledge in focus and the cells rather out of focus.

7. **A. sendaicus, N.E.Br.** Pl. 1, fig. 1, and pl. 4, figs. 6–8. Valve like that of *A. Ehrenbergii*, Bail., in general appearance,

but in the adult state much larger. Primary rays 25–43, sometimes entirely black, sometimes like slender clear lines with dusky or shadowy edges, and on the inner surface the free edge is usually more broadly winged than in *A. Ehrenbergii*, and they are connected by a membrane at the centre in the same way; secondary and tertiary rays also like those of *A. Ehrenbergii*. The cells are usually much larger, and in each row are usually arranged in groups of 2–4 or more, and closely contiguous in those groups, and on the inner surface the concentric and some of the radial spaces are often, but not always, much broadened in a wing-like manner so as to either surround the groups of cells or overlap their ends, from this cause, on the inner surface, the cell-groups are often seen as it were through elliptic or oval window-like openings, which are always quite absent in *A. Ehrenbergii*.

Viewed binocularly the contour is very like that of *A. Ehrenbergii*, Bail.—*A. Ehrenbergii*, Schmidt, Atl., t. 68, f. 1 (inner surface, rather poor figure), and Wolle, Diat. N. Amer., t. 91, f. 1, not of Bailey. "A form related to *A. indicus*," Schmidt, Atl., t. 201, f. 2–6. *A. ornatus* and *A. Ehrenbergii*, Van Heurck, Treatise on Diat. pp. 506 and 507, f. 255 and 256, not of other authors.

Japan: At Sendai, and Kamtschatka, fossil (and living ?).

Just as there are species among the flowering plants growing in Japan that are representatives of species growing in North America, being closely allied and very similar to them, yet constantly differing in certain characters, so this species of *Arachnoidiscus* is evidently the representative of *A. Ehrenbergii* of the West Coast of North America, and distinguished from the latter by its larger size, and by the cells being mostly in groups of 2–3 as represented on pl. 1, fig. 1, or in groups of 4–6 forming short rows as shown on pl. 4, figs. 6–7, and on the inner surface these groups are sunk much below the surface level and often seen through a window-like opening as represented on pl. 4, fig. 8. In fig. 7 on this plate they are represented as seen at the "white-dot" focus which causes them to appear slightly raised above the surface, and at this focus no structure can be detected on the cell-membranes, but at a slightly lower focus the cells appear in pits and the dots upon their membranes can be resolved with sufficient magnification. Pl. 4, fig. 6 represents part of a valve as seen with a 1/6th, and fig. 7 as seen with a 1/12th objective, both inner surface views.

Among the Japanese specimens seen of this species are some that I regard as being probably hybrids between it and *A. ornatus*, Ehr., and one of these is represented on pl. 5, fig. 1, to which the name **A. hybridus, N.E.Br.** may be given, as it does not quite agree with either *A. ornatus* or *A. sendaicus*.

8. **A. russicus, Pant.** Valve of medium size. Primary rays 16–24, penetrating $\frac{3}{4}$–$\frac{4}{5}$ of the way in to the centre, slender, never (so far as seen) so broad as figured by Pantocsek, more or less zigzag and narrowly white along the centre with blackish edges or entirely black throughout their length; on the inner surface they are raised and girder-like, but are without a connecting membrane at the centre; secondary rays usually about $\frac{1}{4}$–$\frac{1}{3}$ as long as the primary; tertiary rays conspicuous as short, stout, black lines at the margin. Central area in some valves with a large, irregular central space, in others with the whole of it filled with 3–4 irregular circles of small roundish or oval cells separated by spaces as broad as or broader than their greater diameter; no valve seen with linear cells at the centre. Cells in 13–20 series or very irregular circles, rather large; the rows between the rays usually, but not always, alternating at the rays, all roundish or oval in general outline, entire or slightly lobed under high magnification. Concentric spaces varying from half as broad to as broad as the greater diameter of the cells; radial spaces about $\frac{1}{2}$–$\frac{2}{3}$ as broad as the diameter of the cells. Marginal ledge broad, about $\frac{1}{4}$–$\frac{1}{2}$ as broad as a marginal space between two primary rays.

Viewed binocularly the outer surface is very slightly depressed from near the margin to the centre, with the areas between the rays slightly convex and very precipitous at the margin.—*A. russicus*, Pantocsek, Foss. Bacill. Ungarns., v. 2, p. 112 (1889), and v. 3, p. 14 (as *A. rossicus*), t. 15, f. 226 (1905). *A. rossicus*, De Toni, Sylloge Alg., v. 3, p. 1312. *A. simbir-*

skianus (on plate) and *A. simbirscianus* (at description), Pantocsek, Foss. Bacill. Ungarns., v. 3, p. 14, t. 15, f. 223 (1905); De Toni, Sylloge Alg., v. 3, p. 1913, name only. *A. rossicus* and *A. simbirskianus*, Pantocsek in Verhandl. des Vereines f. Natur- und Heilkunde zu Pozony (Presburg), v. 25, p. 14, descriptions only. *A. indicus*, Witt in Verhandl. Russisch-Kaiserl. Mineral Gesellsch. St. Petersb., 1886, p. 153 (and reprint p. 17), t. 8, f. 4, not of Ehrenberg nor other authors.

European Russia: at Ananino and Kuznetsk in Simbirsk district, fossil.

Described from Simbirsk material on slides 5455, 5457, 5514 and 11173 in the British Museum, and from specimens in my own and other collections.

Although Pantocsek has described and figured this under two names and others have accepted them as two species, I cannot find any other distinction than size in either his description or figure of the two supposed species. Size of valve and number of rays taken alone are not of specific value in this or other genera if other characters are identical. I have seen specimens agreeing with both figures (except as to the stoutness of the rays, which are badly represented) and find no specific difference in them.

9. **A. oamaruensis, N.E.Br.** Pl. 5, figs. 2–3. Valve varying according to age or sex from small to large. Primary rays 14–31, slender, black or black-edged for all their length and penetrating to between the cells of the second or third or more rarely to only the fourth circle and there uniting with the white concentric space between the second and third or third and fourth circles, which, combined with the space between the first and second circle, form a perforated ring around the moderately large central space, or sometimes black-edged only to the ninth or eighth circle of cells and entirely white thence to the first circle of cells; on the inner surface they are prominent and girder-like for all their length, but are without a connecting membrane at the centre; secondary rays black or black-edged for $\frac{1}{4}$–$\frac{1}{2}$ the length of the primary, but usually detectable as white spaces farther in towards the centre; tertiary rays in young specimens repre-

sented by short black lines at the margin, and in larger specimens like the secondary but much shorter. Cells in 13–32 regular or somewhat irregular and rather crowded circles, rather large, with the rows opposite or alternate at the rays ; those of the first circle linear or wedge-shaped on different valves or intermingled on the same valve ; the other cells nearly circular, or quadrate or trigonous, entire or slightly lobed, rather closely placed. Concentric spaces $\frac{1}{3}$–$\frac{1}{2}$ as broad as the greater diameter of the cells, and the radial spaces narrower. Marginal ledge narrow, varying in large valves from about one-seventh to (in small valves) one-quarter as broad as a marginal space between two primary rays.

Viewed binocularly the outer surface of the valve is rather flat or slightly concave with the central area more or less raised and the areas between the primary rays appearing slightly convex, with a precipitous slope to the margin.—*A. Ehrenbergii* var. *oamaruensis*, Schmidt, partly as to Atlas, t. 147, f. 1 and 3, not as to 2 and 4. *A. Ehrenbergii* var. *deficiens*, Grove in Schmidt, Atl., under t. 153, and Index, p. 14, partly.

New Zealand : at Oamaru, fossil.

When originally figured by Schmidt this species was confused with and considered to be the same as *A. deficiens*, N.E.Br., both being published as a mere variety of *A. Ehrenbergii*, Bail. Grove, however, rightly noticed that two very distinct species were included under Schmidt's name, but added to the confusion by citing figs. 2 and 3 of t. 147 for his *A. Ehrenbergii* var. *deficiens*, whereas fig. 3 unquestionably belongs to the species I name *A. oamaruensis*, and fig. 2 to *A. deficiens*. So that it would seem that the real differential characters were not noticed by either author.

Although similar to *A. Ehrenbergii*, Bail., in general characters, the entire absence of the connecting membrane at the centre on the inner surface, the much narrower marginal ledge, the less distinctly lobed cells and the very different locality and fossil nature at once distinguish it from that species.

10. **A. hungaricus, N.E.Br.** Pl. 5, fig. 6. Valve of medium to large size. Primary rays 24–44, slender, black or white with

black edges, usually the black edges vanish at varying distances between the third and eighth circle of cells from the centre, where they blend with or become white like the spaces between the cells, ocasionally they penetrate to the first circle of cells, prominent and girder-like on the inner surface, without a connecting membrane at the centre; secondary rays short, but variable, sometimes not longer than the breadth of the marginal ledge, at others (when growth is taking place) $\frac{1}{4}$–$\frac{1}{2}$ as long as the primary; tertiary rays quite absent or indistinguishable on outer surface. Central space rather large, often with irregular dots or markings upon it. First ring of cells linear in some valves and in others smaller and oval or wedge-shaped; the other cells small, oval or oblong, sometimes not in pits, and sometimes in distinct pits with prominent concentric spaces between the rows, arranged in 14–25 concentric circles with the rows opposite at the rays. Concentric spaces as broad as or broader than the cells are long; radial spaces usually narrower than the cells are broad. Marginal ledge broad and $\frac{1}{3}$–$\frac{1}{2}$ as broad as a marginal space between two primary rays.

Viewed binocularly the outer surface is flattish or more or less concave, with the central part slightly raised, and the areas between the rays are slightly convex and have a very shallow precipitous slope to the margin.—*A. Ehrenbergii* vars. *californica* and *indica*, Pantocsek, Foss. Bacill. Ungarns., v. 1, part 1, p. 69, t. 19, f. 170–171, not of other authors.

Hungary and Czecho-Slovakia: at Nagy Kurtos, Kekko, Szakal and St. Peter, fossil.

Fig. 6 on pl. 5 is made from a Nagy Kurtos specimen. Although Pantocsek has given three figures of this as representing three separate varieties of it, only the two figures above quoted belong to it and merely represent the upper and lower valves of the same species, and not different varieties in any sense of the word. Nor is it in any sense a variety of *A. Ehrenbergii*, Bail., differing conspicuously by the primary rays not ending in such a regular ring around the centre, the absence of tertiary rays (except when some of the secondary rays are growing in towards the centre and an increase in size is taking place), and a total absence of a connecting membrane between the rays at the centre on the inner surface, as well as the widely different locality.

For the other figure (fig. 169), see 11, *A. similis*, N.E.Br.

11. **A. similis, N.E.Br.** Valve of medium size. Primary rays about 20, represented as penetrating only to the fifth circle of cells, slender, blackish, prominent and girder-like on the inner surface and there connected by a membrane at the centre; secondary rays about half as long as the primary; tertiary rays stout and conspicuous, rather shorter than the width of the marginal ledge. Central space scarcely as broad as the marginal space between a primary and secondary ray. Cells in about seventeen concentric rings; the first circle linear, but probably of circular cells in the opposing valve; all the other cells represented as rather small, separate and roundish, with the rows opposite at the rays. Marginal ledge very broad, its width about equalling a marginal space between a primary and a secondary ray.—*A. Ehrenbergii*, Pant. Foss. Bac. Ung., v. 1, part 1, p. 69, t. 19, f. 169 (not figs. 170 and 171), not of Bailey.

Hungary: at Elesd, fossil.

I have not seen this species and describe it from Pantocsek's figure, which represents it as differing from *A. hungaricus*, N.E. Br., with which Pantocsek has confused it, by the presence of tertiary rays and a connecting membrane at the centre on the inner surface, and by having a much broader marginal ledge. From *A. Ehrenbergii*, Bail., it differs according to the figure by its primary rays being apparently dusky (not black), and penetrating to only the fifth circle of cells, by the tertiary rays not extending across the marginal ledge, and apparently not very clearly defined, and by being fossil and in a very different locality. Probably if examined side by side other distinctions would be apparent, as photographs do not portray some particulars that are easily perceived under the microscope.

12. **A. Adamsii, N.E.Br.** Pl. 5, fig. 4. Valve large. Primary rays 22 in the only specimen seen, slender, black or black-edged with clear undulating mid-line, penetrating only to the sixth circle of cells or between $\frac{2}{3}$ and $\frac{3}{4}$ of the way in to the centre

and then blending with the clear spaces separating the cells, but traceable at a certain focus; on the inner surface they are but slightly prominent above the general surface and are not girder-like nor winged, and are without a connecting membrane at the centre; secondary rays half or more than half as long as the primary; tertiary rays about one quarter as long as the secondary. Central space of moderate size. Cells in 20–22 regular concentric circles, with the rows opposite at the rays; those of the first circle wedge-shaped, probably linear in the opposing valve; those between the rays rather large, lobed under high magnification. Concentric spaces about half as broad as the cells are long; radial spaces very much narrower. Marginal ledge narrow and nearly or quite one-sixth as broad as a marginal space between two primary rays.

Viewed binocularly the centre is slightly elevated into a broad truncate cone, the rest of the surface being fairly level, except that the areas between the rays form slight convex ridges, with the rays in grooves.

California: Redondo Beach, fossil.

This species is easily recognised by its slender black or black-edged primary rays penetrating only to a little more than two-thirds of the way in to the centre, and its large and fairly evenly separated cells. It has some affinity with *A. hungaricus*, N.E.Br., but the presence of conspicuous tertiary rays, as well as the very different habitat, at once distinguish it from that species. The type is in the collection of Mr. F. Adams, after whom I have much pleasure in naming it. The figure is from a drawing of the type $\times 360$ diameters.

13. **A. deficiens, N.E.Br.** Pl. 5, fig. 5. Valve of medium to large size. Primary rays 20–35, slender, slightly zigzag, blackish or with a white zigzag mid-line, or, in very large specimens, sometimes black at the marginal part and white at their inner ends where they vanish at about two-thirds of the way in to the centre, slightly projecting on the inner surface as thin plates that merge into the substance of the shell towards the centre without a connecting membrane; secondary rays $\frac{1}{12}$ to $\frac{1}{4}$ of the length of the primary; tertiary rays absent. Central

space irregularly dotted or reticulated. Cells rather large; in some valves the first circle consists of large linear cells whose outer ends are more or less intermingled with or contiguous to the surrounding cells or occasionally separated from them by a clear space; in other valves the linear cells are absent; the remaining cells of the central area inside where the rays end are irregularly arranged, somewhat circular or oval in general outline and sunk in hexagonal pits; those between the rays are somewhat oblong or rectangular and arranged in rows that alternate at the rays and do not form regular concentric circles, all sunk in pits; concentric spaces about half or less than half as broad as the cells are long; radial spaces much narrower. Marginal ledge narrow or not very broad, its free margin nearly straight between the rays.

Viewed binocularly the surface is bun-shaped or shallowly convex to near the margin, where it slopes precipitously, and the central space seems slightly elevated.—*A. Ehrenbergii* var. *oamaruensis*, A. Schmidt partly, as to Atlas, t. 147, f. 2 and 4, not as to f. 1 and 3. *A. Ehrenbergii* var. *deficiens*, Grove in A. Schmidt, Atlas, under t. 153, and Index, p. 14, partly.

New Zealand: Oamaru deposits, fossil.

At the place quoted Grove cites figs. 2 and 3 of t. 147 as being his *A. Ehrenbergii* var. *deficiens*, but this is certainly an error, as fig. 3 is certainly the same as fig. 1 of that plate, which is *A. oamaruensis*, N.E.Br. and quite distinct from fig. 2.

It is difficult to understand why this should have been associated with the Californian *A. Ehrenbergii*, Bail., since its structure is so entirely different. Its primary rays do not extend in so far and have no connecting membrane, tertiary rays are absent, its cells are different in structure and in the central area are irregularly arranged and sunk in faint hexagonal pits, which, on a dry-mounted specimen I have, bear at each angle a minute elevated knob, like those at the angles of *Triceratium favus*, but they appear absent from a specimen mounted in styrax, and I did not notice them on other specimens seen previously. It also comes from a widely different locality. In the British Museum collection it is represented on slides 30816, 30818, 30820, 30823, 31494, 32809 and 33205.

14. **A. splendens, N.E.Br.** Valve of medium size. Primary rays about 34, penetrating to among the mass of large cells mentioned below and there vanishing, moderately broad, white, with black edges for about one-third of their length ; secondary rays nearly half the length of the primary ; tertiary rays apparently very short, but not very distinctly represented in the figure. Central space very small, surrounded by a circle of eight large linear cells having eight small circular cells alternating with their outer ends ; these are closely surrounded by a crowded mass of small circular cells in 4–6 irregular series ; outside this central mass the cells gradually increase to a very large size, arranged in more regular series and somewhat crowded, occupying a zone from about $\frac{1}{5}$–$\frac{2}{5}$ of the way from centre to margin ; outside this zone of large cells they gradually decrease in size, becoming very small near the margin, forming numerous closely placed concentric circles. At their inner ends there is only one cell between each pair of rays for four or five successive circles, but near the margin there are 3–4 cells between each pair of rays. Marginal ledge apparently about one-fifth as broad as a marginal space between two primary rays.—*A. Ehrenbergii* var. *splendens*, J. Brun in Le Diatomist, v. 2, p. 232, t. 23, f. 7.

West Indies : Barbados, at Clealand and Mount Hillaby, fossil.

This species is so utterly different from *A. Ehrenbergii*, Bail., that it is difficult to understand how it could possibly have been associated with that species. I have not seen a specimen of it, but judge from the figure, which represents the inner surface of the valve, that there is no connecting membrane between the rays at the centre.

15. **A. indicus, Ehrenb.** Pl. 5, figs. 8–9. Valve of small to medium size, thin and rather transparent. Primary rays 15–30, very slender, much more slender than the photographs represent, black or white with black edges for their entire length according to focus, penetrating into the third or second circle

of cells, slightly prominent on the inner surface but without a connecting membrane at the centre; secondary rays $\frac{1}{4}$–$\frac{1}{2}$ as long as the primary; tertiary rays absent or scarcely distinguishable from the short, black lines that occur all round the margin. Central space rather small or of medium size, with irregular faint markings upon it. Cells in 9–23 regular concentric circles with the rows opposite at the rays, not or scarcely sunk in pits; first circle of linear or wedge-shaped cells or of both forms intermingled; the other cells moderately large and mostly more or less oblong or rectangular in general outline, with 6–7 in the rows at the inner ends of the secondary rays, often nearly twice as long as broad, often appearing lobed but sometimes entire under high magnification. Concentric and radial spaces narrow, about half the width of the cells in thickness. Marginal ledge about $\frac{1}{5}$–$\frac{1}{4}$ as broad as a marginal space between two primary rays, its free margin slightly concave or nearly straight between the rays, and the outer margin marked with short lines (not mere dots).

Viewed binocularly the valve is nearly flat or but very slightly depressed at the central area, and towards the margin becomes very gradually and slightly elevated and then very gradually slopes to the margin, or in other words its contour is something like a very shallow saucer turned upside down, with the areas between the rays slightly convex.—*A. indicus*, Ehrenb., Microgeol., p. 165, t. 36, f. 34 (1854), and Micr. Dict., ed. 1875, p. 67, t. 42, f. 3; not of A. Schmidt nor of other authors.

Nicobar Islands: at Nancowry, fossil.

A. indicus, Ehrenb., is so very distinct from the various species from California, Russia, Hungary, Behring Sea and New Zealand that have been named *A. indicus* by Schmidt, Witt, Mann and Pantocsek, that it is quite impossible to believe that those authors could have compared their specimens with Ehrenberg's excellent figure of *A. indicus*. In Reise der Fregatti Novara, v. 1, p. 26 (1870), Grunow has mentioned (but not figured) this species, and has remarked of it that it is "perhaps identical with *A. Ehrenbergii*, Bailey." This again is a most extraordinary statement for any diatomist to make, as the structure of the two species is so totally different.

Apart from Ehrenberg's original figure of *A. indicus*, which is published in a book that is now almost unobtainable, and that, in the Micrographic Dictionary no figure of this diatom has elsewhere been published, so that the two figures given on pl. 5, figs. 8 and 9 are the first modern and correctly named illustrations of this species that have appeared. They were photographed from Nancowry (the type locality) specimens, which were found in company with *A. ornatus*.

For A. indicus of other authors see 24, A. beringensis; 23, A. cibdelus; 19, A. decorus; 10, A. hungaricus; 22, A. lepidus; 21, A. evanescens and var. paulus, and 8, A. russicus of this book.

16. **A. clarus, N.E.Br.** Pl. 6, figs. 1–2. Valve small to medium size, very clear. Primary rays 13–20, rather slender, penetrating sometimes to the second and sometimes only to the fourth circle of cells, white with black edges for a part or nearly all their length, or at another focus black, the white part is sometimes or at one focus not very conspicuous towards the centre; on the inner surface they are raised above the general surface near the margin or for most of their length, i.e., at the parts that appear black-edged, and are without a connecting membrane at the centre; secondary rays about $\frac{1}{4}$–$\frac{1}{3}$ as long as the primary; tertiary rays absent. Central space of moderate size, sometimes dotted. Cells in about 12–16 concentric circles, with the rows opposite or here and there alternating at the rays, of moderate size, not sunk in pits (see note); those of the first circle linear, cuneate, oval or circular, the others from circular to oblong, not lobed. Concentric spaces about $\frac{1}{2}$–$\frac{2}{3}$ as broad as the cells are long; radial spaces narrower and about $\frac{1}{4}$–$\frac{1}{2}$ as broad as the cells are long. Marginal ledge narrow, less than one-quarter as broad as the marginal space between two primary rays, and marked with small dots at the margin.

Viewed binocularly the outer surface is distinctly depressed or saucer-shaped at the central area, and from the more elevated marginal part the contour rather abruptly slopes down to the margin like that of an inverted cake-tin, with the areas between the rays slightly convex.—*A. Grevilleanus*, Truan and Witt, Jérémie, p. 11, t. 2, f. 12, not of Hardman nor of Schmidt.

West Indies: Barbados, at Newcastle; Hayti, at Jérémie, fossil.

Of this species I have been able to examine the type specimen of *A. Grevilleanus*, Truan and Witt, in the Adams collection, on a slide labelled "Typen platte III" and "T.S. 221," and find that it is the same species as the specimens seen from Barbados in my own and Mr. J. A. Long's collection.

A. clarus is closely allied to *A. indicus*, and at one time I thought it might be a variety of that species, but the widely different locality seemed to forbid that assumption, and upon a more careful comparison I find they differ as follows: The primary rays when in correct focus are nearly or quite twice as stout as those of *A. indicus*, although they are not represented as being so in the figures, for photographs cannot represent every detail on one plane as the eye is able to see it; the marginal ledge is narrower; and the contour when viewed binocularly is entirely different, the abrupt slope of the outer portion of the valve down to the margin being very different from the much slighter, longer and far less abrupt slope of *A. indicus*, which is altogether a flatter diatom. These differences, combined with the widely separated localities proclaim them to be distinct although nearly allied species.

Figures 1 and 2 on plate 6, representing two specimens of *A. clarus* from Newcastle are excellent examples of the effects produced by different illumination. For fig. 1 a large cone of light has been used, but the cells are not quite in focus; when fig. 2 was taken, the diaphragm was more closed and a smaller cone of light used, the result being that the cells appear rather larger and the concentric spaces narrower than they really are when seen with a full cone of light at the correct focus. In fig. 2 some of the cells also appear to be in pits; this is a false effect, due to the tilt of the valve and the smaller cone of light; the small part where the cells are represented at the "white-dot" focus is slightly above the true surface focus, and the opposite part (where the rays seem accompanied by lateral whitish lines that produce the effect of the rays of a star) is below the surface focus and practically represents the inner membranes of the cells, so that they appear sunk in deep pits and larger than they really are.

17. **A. giganteus, Pant.** Pl. 6, fig. 6. Valve of medium to large size, white. Primary rays 20–26, stout, white, with black edges at the tips only, traceable to the third or second series of cells from the centre and without a connecting membrane on the inner surface ; secondary rays mostly $\frac{1}{3}$–$\frac{1}{2}$ as long as the primary ; tertiary rays about as long as the width of the marginal ledge and sometimes not very distinct. Central space of moderate size. First circle of cells irregular, composed of linear, cuneate or oval cells intermixed ; outside of this circle the valve is covered with separate and not crowded, roundish or faintly lobed cells of large size, which at a certain focus with a 1/6th lens appear marked with a small central ring, causing Pantocsek to describe them as papillate ; the rows between the rays alternate at the rays. Concentric spaces as broad as or broader than the greater diameter of the cells ; radial spaces usually narrower. Marginal ledge narrow (less broad than figured by Pantocsek) and about one-sixth as broad as a marginal space between two primary rays.

Viewed binocularly the outer surface of the valve is slightly depressed at the central part, and at the outer part curves over the margin in a steep curved slope.—*A. giganteus*, Pantocsek, Foss. Bacill. Ungarns., v. 2, p. 111 (1889), and v. 3, p. 14, t. 2, f. 26 (1905) ; and in Verhandl. der Vereins für Natur und Hilkunde zu Pozony. (Presburg), v. 25, p. 14, description only ; De Tonis Sylloge Alg., v. 3, p. 1312.

European Russia : at Kuznetsk, fossil.

A. giganteus appears to be a very rare species, as it is not represented in either the Adams or the British Museum collection. The photograph by which I illustrate it was made from a specimen in the collection of Mr. J. A. Long, and I have another that Mr. Long gave to me. These are the only specimens I have seen of it. The whiter part of fig. 6 represents the valve as seen at the correct focus. The small ring-like mark that can be seen with a 1/6th lens on the cells of this species is a marked peculiarity, although only due to some diffraction image, not to structure, as greater magnification clearly demonstrates.

18. **A. spissus, N.E.Br.** Pl. 3, fig. 6. Valve of the only specimen seen of medium size. Primary rays 20, penetrating to the third or second circle of cells as very slender blackish lines and then as slender clear spaces between the cells to the central space; on the inner surface prominent and girder-like for all their length and connected by a membrane at the centre; secondary rays about one-quarter as long as the primary; tertiary rays very short. Central space of moderate size. Cells in about 16–17 regular concentric circles, with the rows opposite at the rays; those of the first circle wedge-shaped, but probably linear in the opposing valve; those of the other circles larger and sunk in pits, somewhat rectangular or quadrate, entire, all about equal in size except near the margin, crowded. Concentric spaces about $\frac{1}{4}$–$\frac{1}{3}$ as broad as the cells are long; radial spaces very much narrower. Marginal ledge broad, nearly or quite as broad as a marginal space between a primary and secondary ray.

Viewed binocularly this appears to be a flat species, with the areas between the primary rays slightly convex for most of their length, then becoming forked into two convexities near the margin where the secondary ray appears to be depressed.

California: at Los Angeles, fossil.

Described from a specimen in the collection of Mr. F. W. Parrott, on a slide mounted by Mr. W. A. Firth, and mingled with various other diatoms from the same locality. It is distinguished from nearly all other species by its large and crowded cells, all separated concentrically and radially by very narrow spaces, and are not lobed under high magnification. They are rather difficult to resolve, but when they are resolved are seen to be irregularly dotted and the dots irregular in shape. The figure is from a drawing I made from Mr. Parrott's specimen.

19. **A. decorus, N.E.Br.** Pl. 6, fig. 3. Valve of medium to large size. Primary rays 12–36, penetrating to the third or

second circle of cells, stout or somewhat slender, entirely white or with black points and narrow black edges for one-third to nearly half their length on the outer surface ; on the inner surface they appear to be raised as slight ridges towards the margin and are often black-edged throughout their length, and are without a connecting membrane at the centre ; secondary rays half as long as the primary ; tertiary rays very short. Central space one-quarter to more than half as broad as a marginal space between two primary rays. Cells in 9–23 concentric circles with the rows usually opposite but sometimes alternate at the rays ; the first circle of linear or round cells on different valves, and often separated from the second circle by a concentric space as broad as the cells are long ; all other cells of moderate size, round, oval or oblong, separate or 2–3 together, and sunk in pits, subentire or slightly constricted at the middle, but scarcely lobed, and with very narrow black margins. Concentric spaces from nearly as broad as to broader than the cells are long ; radial spaces usually narrower than the cells are broad. Marginal ledge usually rather narrow and $\frac{1}{6}$–$\frac{1}{4}$ as broad as a marginal space between two primary rays.

Viewed binocularly the outer surface is fairly flat or slightly concave from near the rim to the centre and not raised into convex ridges between the rays, and with a steep but not vertical slope to the edge ; the inner surface, however, sometimes appears to be depressed towards the centre or somewhat saucer-shaped. —*A. Grevilleanus*, A. Schmidt, Atl., t. 68, f. 5, and t. 73, f. 3 (which is also named *A. Ehrenbergii* var. *evanescens*, Grun), and Wolle, Diat. N. Amer., t. 91, f. 5, and De Toni Sylloge Alg., v. 3, p. 1312 (not *A. Grevilleanus*, Hardm.). *A. indicus*, var. A. Schmidt, Atl., t. 68, f. 6, and t. 73, f. 2 ; Wolle, Diat. N. Amer., t. 91, f. 6 and 7, and Boyer in Proc. Acad. Nat. Sc. Philad., 1927, p. 69 ; De Toni Sylloge Alg., v. 3, p. 1312 partly, not *A. indicus*, Ehr.

California : at Monterey and Santa Monica, fossil.

Schmidt has made an extraordinary mistake in identifying this very distinct species with *A. indicus*, Ehrenb., and *A. Grevilleanus*, Hardm., demonstrating that he could not have consulted the original figures of these species nor paid any heed to their localities. The true *A. Grevilleanus*, Hardm., is a small and rare species from Barbados, and evidently identical with that figured by Schmidt as *A. barbadensis*. While that he figures as *A. Grevilleanus* is obviously only a figure of the inner surface of the very same species figured on the same plate as *A. indicus*. He has figured several species as being forms of *A. indicus* not one of which is at all like the true *A. indicus*, Ehr., which is a native of the Nicobar Islands.

A. decorus provides the microscopist with a trick diatom, for at a certain adjustment the rays appear to be depressed and the cells raised above their level. This is the appearance represented in Schmidt's Atlas, t. 73, fig. 2, and upon viewing this diatom when presenting that appearance it would scarcely be possible to realise that this view does not exhibit its true structure, for when all adjustments are correctly made the cells should and will be seen sunk in slight pits below the level of the rays.

20. **A. abnormis, N.E.Br.** Valve large. Primary rays in the specimens seen 38–41, irregularly bent or curved in a sinuous manner or oblique, unequally spaced at the margin, slender, white with black tips, and penetrating four-fifths of the way in to the centre and then vanishing among the central mass of cells; on the inner surface they are all nearly even with the general surface except near the margin where they are slightly prominent, and are without a connecting membrane at the centre; secondary rays one or sometimes two between each pair of primary; tertiary rays, none. Central space irregular in outline about as broad as the average width between two primary rays at the margin. Cells all similar and irregularly arranged, nowhere forming concentric rings, or the first circle linear and short, subregular, all rather small and separate, oval, oblong, irregularly circular or hexagonal in outline, not lobed and more or less sunk in pits, especially in the central area; seen at one focus the concentric and radial spaces separating the cells seem of about equal thickness, but at the correct focus the concentric spaces are usually broader than the radial spaces. Marginal ledge narrow and scarcely broader than the length of an average cell.

Viewed binocularly the greater area of the outer surface is depressed, with the centre very shortly raised into a broad cone, and near the margin is convexly curved over to the edge; in places it is uneven, and between the rays is nearly flat, with the cells in slight pits.

California: at Santa Monica, fossil.

Of this remarkable form I have seen only the specimen in my own collection and one other, but I think it probable that the form represented in Schmidt's Atlas, t. 147, fig. 8, from Santa Monica belongs to this species. It differs from all others by the irregularly bent and often obliquely arranged primary rays.

21. **A. evanescens, N.E.Br.** Valve of small or medium size and very white in appearance. Primary rays 13–20, penetrating to the central space as seen at a focus in which they appear as slightly elevated ridges, or to about the sixth circle of cells as seen at another focus, and rather indistinct, stout, white, with black and sometimes notched edges for about $\frac{1}{6}$–$\frac{1}{3}$ of their length, and without a connecting membrane at the centre on the inner surface; secondary rays $\frac{1}{3}$–$\frac{1}{2}$ as long as the primary or falsely appearing as primary rays at a different focus; tertiary rays about as long as or slightly longer than the breadth of the marginal ledge. Central space rather large. Cells in 7–15 regular or irregular concentric circles and not sunk in pits, moderately large (or in a San Redondo specimen, small) and distinct from one another, oval or irregularly elliptic, the rows between the rays usually opposite (but sometimes alternate) at the rays. Concentric spaces broad, and from nearly as broad as to twice as broad as the cells are long; radial spaces from nearly as broad to twice as broad as the cells are broad. Marginal ledge narrow and $\frac{1}{4}$–$\frac{1}{3}$ (but in a San Redondo specimen $\frac{1}{6}$) as broad as a marginal space between a primary and secondary ray.

Viewed binocularly this species has a very flat surface.—*A. indicus* var. A. Schmidt and *A. Ehrenbergii* var. *evanescens*, Grunow ex. A. Schmidt's Atlas, t. 68, f. 7 only, not of other figures.

California: at Monterey and San Redondo, fossil.

The San Redondo specimen seen had the black-edged part of the rays shorter, the cells smaller and the marginal ledge narrower than in the Monterey specimens, but otherwise seems quite the same.

A. evanescens is nearly allied to *A. decorus*, N.E.Br., but is at once distinguished from the latter by its much broader rays, which are also not black-edged for so far in from the margin and the cells are not sunk in pits. It is a very white species.

Var. **paulus, N.E.Br.** Valve very small, with 15–16 primary rays much more slender than those of the type, penetrating to about half-way in to the centre (to the fourth or third circle of cells), slightly zigzag and black or black-edged for nearly all their length. Otherwise similar to the type.—*A. indicus* small var. ? Schmidt, Atl., t. 68, f. 9 and 10, and Wolle, Diat. N. Amer., t. 91, f. 10 and 11.

Locality not stated: Gazelle Expedition.

I have not seen any specimen of this and describe it from the figures. Until better known it is not possible to determine if the figures represent merely young (or male ?) individuals of *A. evanescens* or a distinct species, so I place it provisionally as a variety of *A. evanescens*.

The name *A. Ehrenbergii* var. *evanescens*, according to Schmidt, was given to two very different species, neither of which are at all like *A. Ehrenbergii*, Bail., either in structure or appearance. No description of any kind is given of either of them, but I use the varietal name for the diatom first published with that name.

The confusion in the nomenclature of this genus that has existed for fifty years was begun by A. Schmidt when he issued in 1881, t. 68, and in 1882, t. 73 of his Atlas, for, with the exception of *A. ornatus* and its varieties and one variety of *A. Ehrenbergii*, every other diatom figured on those two plates is wrongly named, hence diatomists have been misled by these wrong determinations, so that erroneously named slides abound.

Among the incorrectly named species figured on these two plates is that above described as *A. evanescens*. This Schmidt names "*A. indicus* var.," as above quoted, and states that

Grunow calls it " *A. Ehrenbergii* var. *evanescens*," and on t. 73 under fig. 3, he states that Grunow wishes to refer figs. 2 and 3 of that plate also to that variety, but does not mention where Grunow has stated this. So that according to this statement Grunow considered t. 68, fig. 7, and t. 73, figs. 2 and 3 all to represent his *A. Ehrenbergii* var. *evanescens*. Schmidt, however, names them otherwise, for he calls t. 68, fig. 7, and t. 73, fig. 2, *A. indicus* var., while t. 73, fig. 3 he names " *A. Grevilleanus*," correctly stating that it (fig. 3) is the same as that figured under the same name on t. 68, fig. 5. But he has altogether failed to recognise that these figures merely represent the inner surface of the very same diatom of which he figures the outer surface on t. 68, fig. 6, and t. 73, fig. 2, under the name of " *A. indicus* " ! So that t. 68, figs. 5 and 6, and t. 73, figs. 2 and 3, all belong to one species which I describe as *A. decorus*, and which bears not the least resemblance in structure to either *A. indicus*, Ehr., *A. Ehrenbergii*, Bail., or *A. Grevilleanus*, Hardm.

I wish also to make clear that I have given the name *A. evanescens* to the diatom first published with that varietal name on t. 68, fig. 7, because in the second edition of his *Atlas* Schmidt has made wrong statements of the dates of issue of the first edition, which are likely to mislead those who have only the second edition, in which it is stated that t. 68 was first issued on Oct. 15, 1878, and that t. 73 was first issued on July 1, 1876. That is to say, t. 73 was issued two years before t. 68. Both statements are entirely wrong, for, of the first edition, t. 68 was issued July 20, 1881, and t. 73 on Jan. 28, 1882, the text with these plates in both editions is otherwise the same.

22. **A. lepidus, N.E.Br.** Valve small. Primary rays 15–22, rather stout, white with black edges and very distinctly zigzag to about one-third of the way in from the margin, penetrating to nearly half-way in to the centre and then vanishing or blending with the spaces between the cells and completely losing the black edges, but often traceable at a certain focus as far in as the second circle of cells, prominent at the marginal part on the inner surface, but without a connecting membrane at the centre ; secondary rays about one-third as long as the

primary; tertiary rays very short. Central space moderately large, often with faint irregular markings at the centre. Cells in about 8–13 irregular circles, with the rows alternating at the rays; the first circle of cells sometimes very small, narrowly oval to nearly circular; outside of this circle the area inside where the black edges of the rays end is occupied by much larger cells that are nearly circular, subquadrate or oblong in outline, distant and irregularly arranged, and at the right focus are seen to be encircled by faint hexagonal outlines, indicating the edges of the pits in which they are sunk, between the rays they become more crowded and arranged in rows alternating at the rays. Marginal ledge narrow, about one-quarter as broad as a marginal space between two primary rays.

Viewed binocularly the outer surface varies from depressed and somewhat saucer-shaped to distinctly convex, and the cells are seen to be sunk in pits, the stout walls of the pits forming a coarse network with acute edges (which are the faint lines seen under monocular vision) between the cells; on the inner surface the cells are also sunk in pits.—"Similar to *A. indicus*," Schmidt, Atl., t. **147**, f. 9, not of other plates nor of Ehrenberg.

New Zealand: Oamaru, fossil.

23. **A. cibdelus, N.E.Br.** Valve small. Primary rays seventeen in the example figured (which represents the inner surface), penetrating to the third circle of cells, stout, white with black edges, which are interrupted towards the centre; connecting membrane apparently represented by a plate extending to near the margin where it connects the secondary rays with the primary; secondary rays about one-quarter as long as the primary; tertiary rays none, and the margin marked with 3–5 dumb-bell shaped or double dots between each primary and secondary ray. Central space about as broad as the marginal space between a primary and secondary ray and marked with a central dot. Cells in 12–13 regular concentric circles, the rows opposite at the rays, all of moderate size, similar, separate and apparently not lobed. The first 4–5 concentric spaces as broad as or broader than the cells are long, the others gradually narrower.—*A. indicus*, Schmidt, Atl., t. 68, f. 8,

according to a note with t. 73 of the first edition, but the note and all reference to the figure (except in the index, p. 14) is omitted from the second edition. Not *A. indicus* of Ehrenberg.

Nicobar Islands: Nancowry, fossil?

The fewer, white and much broader rays, the broader concentric spaces and the curious plate connecting the rays near the margin on the inner surface readily distinguish this from *A. indicus*, Ehr. I have not seen a specimen of it and describe from Schmidt's figure.

24. **A. beringensis, N.E.Br.** Pl. 6, fig. 7. Valve of medium size, white. Primary rays eleven in the specimen seen, penetrating to the second circle of cells, very stout, white, with black edges at the outer ends, not projecting nor with a connecting membrane at the centre on the inner surface; secondary rays half or more than half as long as the primary; tertiary rays very short. Central space very small, about 1½ times the diameter of the larger cells. First circle of cells small and in the valve seen linear, but probably in opposing valves circular or absent as in allied species; the remaining cells large, oblong or somewhat rectangular in general outline, lobed, with a very conspicuous black dot at each corner, sunk in distinct pits and arranged in 10–11 regular concentric circles, with the rows between the rays opposite at the rays. Concentric and radial spaces rather stout and about as broad as or broader than the width of the cells and raised between them into acute edges. —*Hemiptychus indicus*, Mann in Contrib. from the United States Nat. Herb., v. 10, p. 267.

Behring Sea, Albatros Expedition, probably living.

Described and the sketch (fig. 7) made from a specimen in the collection of the late Mr. H. Morland. This species is easily recognised by its very stout white rays and the very distinct black dots at the corners of the cells, which are also black-edged.

25. **A. antarcticus, N.E.Br.** Pl. 6, figs. 4–5. Valve small to medium sized, oval or circular in outline. Primary rays 16–24, often irregularly spaced, penetrating in small specimens to the third circle of cells, but in large examples only to the fourth or fifth circle, and in both cases to about half-way in from the

margin, then more or less merged into the spaces between the cells, or on the inner surface forming a central perforated plate, moderately stout, white with black edges ; on the inner surface they are prominent and girder-like, with narrowly winged margins uniting and blending with the concentric spaces at the central part ; secondary rays $\frac{1}{4}$–$\frac{1}{2}$ (or in growing specimens more than half) as long as the primary ; tertiary rays usually present as short black lines, but sometimes rudimentary or absent in places. Central space moderately large. Cells usually in 6–13 regular concentric series, but sometimes irregular, of moderate size or rather small ; lobed under high magnification ; those of the first circle narrowly linear, or cuneate or oval, with or without linear cells intermingled ; those of the third and fourth circle usually with some or all in groups of 2–3, and on the inner surface each group is sunk in a pit. Concentric spaces at the central part rather broad. Radial spaces between the rays from half as broad to as broad as the cells are wide. Marginal ledge variably narrow or broad.

Viewed binocularly the outer surface is somewhat bun-like or like the shell of a limpet, being flattish or slightly depressed at the centre, then more or less convexly sloping to the rim, where it sometimes descends precipitously to the margin.— *A. antarcticus*, N.E.Br., in English Mechanic, 1920, v. 91, p. 219.

Antarctic Region : Adelie Land at Commonwealth Bay ; living.

26. **A. Grevilleanus, Hardm.** Pl. 6, fig. 8. Valve small. Primary rays 20–33, penetrating to about three-quarters of the way in to the centre then becoming indefinite and vanishing among the central cells, white with black-edged or black zigzag tips ; on the inner surface they are slightly prominent at the tips and even with the general surface elsewhere, without a connecting membrane at the centre ; secondary rays mostly $\frac{1}{5}$–$\frac{1}{4}$ as long as the primary, or longer where growth is taking place ; tertiary rays dot-like or indistinct, black. Central space very small or almost obsolete. Cells in 9–20 irregular series alternating at the rays, the central circle of one valve of 6–10 small linear cells, sometimes nearly crowding out the

central space and with their outer ends mingling with the surrounding cells, on the opposing valve these linear cells are absent; the other cells small and in distinct pits, irregularly arranged at the central part, and between the rays the rows alternate at the rays, nowhere forming unbroken circles. Concentric spaces from nearly as broad as to broader than the cells are long; radial spaces slender. Marginal ledge from very narrow to not more than one-quarter as broad as a marginal space between two primary rays.

Viewed binocularly the outer surface is bun-shaped or convex in a gradual curve from margin to the flattened centre.—*A. Grevilleanus*, Hardman ex. Greville in Trans. Roy. Microscop. Soc. Lond., v. 13, p. 47, t. 5, f. 7 (1865); De Toni, Sylloge Alg., v. 3, p. 1312, not of Schmidt. *A. barbadensis*, Schmidt, Atl., t. 68, f. 11; De Toni, Sylloge Alg., v. 3, p. 1313.

West Indies: Barbados; at Springfield and Cambridge Estates, fossil.

The above description is made from Greville's type specimens at the British Museum and from a specimen compared with them that I possess. It is distinguished by its small size, the very short secondary rays, by the rows of cells alternating at the rays and sunk in pits, and by the few linear cells nearly filling the central space.

INDEX TO THE FIGURES QUOTED WITH INDICATION OF THE SPECIES TO WHICH EACH IS REFERRED IN THIS BOOK.

Abbreviations of the books quoted repeatedly, the remainder being quoted in sufficiently full title.

Pant. F. B. Ung.=Dr. Josef Pantocsek, *Beitrage zur kenntniss der Fossilen Bacillarien Ungarns.* Nagy Tapolcsany. 1886–1889. 8vo.

S. A.=Adolf Schmidt, *Atlas der Diatomaceen-kunde.* Leipzig. 1874–1932. Folio.

Tr. and Witt, Jér.=Alfredo Truan y Luard and Dr. Otto N. Witt, *Die Diatomaceen der Polycystinen-kreide von Jeremie in Hayti.* Berlin. 1888. 4to.

V. H. Tr.=Dr. Henri Van Heurck, *Treatise on the Diatomaceæ.* London. 1896. 4to.

Wolley, D. N. A.=Rev. Francis Wolle, *Diatomaceæ of North America.* Bethlehem, Pa. 1890. 8vo.

N.B.—The figures in this book are copied from Schmidt's Atlas without correction of names.

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barbadensis, S. A., t. 68, f. 11=26, *Grevilleanus.*

Ehrenbergii, Bailey in Wilkes, U. S. Explor. Exped. Algæ, t. 9, f. 9–10=5, *Ehrenbergii.*

,, Janisch in Abhandl. Schlesisch. Gesellsh. Vaterl. Cult., 1862, t. 2A, f. 3 and 11=5, *Ehrenbergii.*

,, Micrographic Dictionary, ed. 1, t. 12, f. 12–13=5, *Ehrenbergii.*

,, Pant. F. B. Ung., v. 1, part 1, p. 69, t. 19, f. 169=11, *similis.*

,, S. A., t. 68, f. 1=7, *sendaicus.*

,, Smith, British Diat., t. 31, f. 256=5, *Ehrenbergii.*

,, Tr. and Witt, Jér., t. 2, f. 8=4, *confusus.*

,, V. H. Tr., p. 507, f. 256=7, *sendaicus.*

,, Wolle, D. N. A., t. 91, f. 1=7, *sendaicus.*

,, var. *californica*, Pant. F. B. Ung., v. 1, part 1, t. 19, f. 170=10 *hungaricus.*

,, ,, ,, Laporte and Lefebure Diat. Rar., t. 2, f. 11=5, *Ehrenbergii.*

,, ,, ,, S. A., t. 68, f. 3–4=5, *Ehrenbergii.*

,, ,, ,, S. A., t. 73, f. 1=1, *ornatus.*

,, ,, ,, Tr. and Witt, Jér., t. 2, f. 8=4, *confusus.*

,, ,, ,, Wolle, D. N. A., t. 91, f. 3=1, *ornatus.*

,, ,, ,, Wolle, D. N. A., t. 91, f. 4=5, *Ehrenbergii.*

,, ,, *deficiens*, Grove in S. A., under t. 147, and t. 153, and Index, p. 14=partly 13, *deficiens*, and partly 9, *oamaruensis.*

Ehrenbergii, var. *evanescens*, Grun in S. A., under t. 68, f. 7=21, ***evanescens.***
,, ,, ,, Grun in S. A., t. 73, f. 3=19, ***decorus.***
,, ,, *indica*, Pant. F. B. Ung., v. 1, part 1, p. 69, t. 19, f. 171=10, ***hungaricus.***
,, ,, *montereyana*, S. A., t. 68, f. 2=5, ***Ehrenbergii* var. *montereyanus.***
,, ,, ,, Wolle, D. N. A., t. 91, f. 2=5, ***Ehrenbergii* var. *montereyanus.***
,, ,, *oamaruensis*, S. A., t. 147, as to f. 1 and 3=9, ***oamaruensis.***
,, ,, ,, S. A., t. 147, f. 2 and 4=13, ***deficiens.***
,, ,, *splendens*, Brun in Diatomist, v. 2, t. 23, f. 7=14, ***splendens.***
,, ,, O'Donoghue in English Mechanic, Dec. 10, 1915=5, ***Ehrenbergii* var. *montereyanus.***

giganteus, Pant. F. B. Ung., v. 3, t. 2, f. 26=17, ***giganteus.***

Grevilleanus, Hardman in Tr. Roy. Micr. Soc., 1865, v. 13, t. 5, f. 7=26, ***Grevilleanus.***
,, S. A., t. 68, f. 5, and t. 73, f. 3=19, ***decorus.***
,, Tr. and Witt,, Jér., t. 2, f. 12=16, ***clarus.***
,, Wolle, D. N. A., t. 91, f. 5=19, ***decorus.***

indicus, Ehrenb. Microgeol., t. 36, f. 34=15, ***indicus.***
,, Micrögr. Dict., ed. 3, 1875, t. 42, f. 3=15, ***indicus.***
,, S. A., t. 68, f. 8, according to a note with t. 73 of ed. 1=23, ***cibdelus.***
,, Witt in Verhandl. Russisch-Kaiserl. Mineral Gesellsch, St. Petersb., 1886 ; (and reprint), t. 8, f. 4=8, ***russicus.***
,, var. S. A., t. 68, f. 6, and t. 73, f. 2=19, ***decorus.***
,, ,, S. A., t. 68, f. 7=21, ***evanescens.***
,, ,, Wolle, D. N. A., t. 91, f. 6–7=19, ***decorus.***
,, ,, Wolle, D. N. A., t. 91, f. 10–11=21, ***evanescens* var. *paulus.***
,, var. ? S. A., t. 68, f. 9–10=21, ***evanescens* var. *paulus.***
,, (similar to) S. A., t. 147, f. 9=22, ***lepidus.***
,, (form related to) S. A., t. 201, f. 2–6=7, ***sendaicus.***

japonicus, Pritchard, Infusoria, ed. 1852, t. 24, f. 18–21=1, ***ornatus.***
,, Beck, Treat. Micr., 1865, p. 13=1, ***ornatus.***

Manii, Hanna and Grant in Proc. Californ. Acad. Science, 1926, t. 12, f. 7–9; and 1932, t. 5, f. 1 ; and Journ. Paleont., 1927, t. 17, f. 5=1, ***ornatus.***

nicobaricus, Ehrenb. Microgeol., t. 36, f. 35=1, ***ornatus.***
,, Microg. Dict., ed. 1875, t. 42, f. 4=1, ***ornatus.***

ornatus, Pritchard, Infusoria, ed. 1861, t. 15, f. 18–21=1, ***ornatus.***
,, Janisch in Abhandl. Schlesisch. Vaterl. Cult., Breslau, 1861, t. 1, f. 3, and 1862, t. 1B, f. 5=1, ***ornatus.***
,, Janisch, Guano, t. 2A, f. 11=5, ***Ehrenbergii.***
,, Japan Fisheries, t. 8, f. 6=1, ***ornatus.***
,, S. A., t. 73, f. 4–6=1, ***ornatus.***
,, Tr. and Witt, Jér., t. 2, f. 15=2, ***Longii.***
,, V. H. Tr., p. 506, f. 255=7, ***sendaicus.***
,, var. *marylandica*, Welsh in Amer. Microsc. Soc., 1915, t. 16, f. 2=1, ***ornatus.***
,, ,, *montereiana*, S. A., t. 73, f. 7=1, ***ornatus* hybrid form.**
,, ,, ,, S. A., t. 73, f. 8–9=1, ***ornatus* var. *montereyanus.***

ornatus, var. *montereianus*, Hanna and Gaylord in Proc. Amer. Assoc. Petrol. Geol., 1925, t. 5, f. 2=1, *ornatus*.
,, ,, ,, Wolle, D. N. A., t. 91, f. 8=1, *ornatus* hybrid form.
,, ,, ,, Wolle, D. N. A., t. 91. f. 9=1, *ornatus* var. *montereyanus*.
,, ,, *obscura*, Forti in Atti del Reale Istituto Veneto di Scienze, v. 72, part 2, and in reprint entitled "Contribuzioni Diatomologiche," 1913, and also in Nuovo Notarisia, 1914, v. 25, figured in each place on t. 4, f. 3–8, and t. 5, f. 5=1, *ornatus* var. *obscurus*.
,, ,, S. A., t. 73, f. 10=3, *major*.

rossicus, Pant.=8, *russicus*.

russicus, Pant. F. B. Ung., v. 3, t. 15, f. 226=8, *russicus*.

simbirscianus, Pant.=8, *russicus*.

simbirskianus, Pant. F. B. Ung., v. 3, t. 15, f. 223=8, *russicus*.

species, O'Donoghue in English Mechanic, Nov. 26, 1816=5, *Ehrenbergii* var. *montereyanus*.
,, S. A., t. 147, f. 8, see under 20, *abnormis*.
,, Shadbolt in Trans. Microscop. Soc., Lond., 1852, v. 3, t. 11, f. 1–5=1, *ornatus*.

DATES OF ISSUE OF THE FIRST 80 PLATES OF A. SCHMIDT'S ATLAS DER DIATOMACEEN-KUNDE.

As the dates of issue of the first edition of plates 1–80 are often wrongly stated in the second edition, the following list of dates as stated on the text issued with the plates of the first edition may be found useful where the priority of a name is in question and the first edition is not available.

Heft.	Plates.	Dates as stated in the First Edition.		Dates of the first issue of the same plates as stated in the Second Edition.
1	1–4	Date not mentioned, but as notices of its issue are published in the *Botanische Zeitung*, July 31, 1874, p. 480, and Nov. 27, 1874, p. 784, and in *Hedwigia*, Aug., 1874, p. 114, it must have been published in the early half of that year.		Jan., 1874.
2	5–8	Jan. 20, 1875	5–6	Jan., 1874

Heft.	Plates.	Dates as stated in the First Edition.	Plates	Dates of the first issue of the same plates as stated in the Second Edition.
3	9–12	March 25, 1875	7–12	July, 1885 (!)
4	13–16	June 25, 1875	13–16	Jan., 1874
5	17–20	June 25, 1875	17–20	July, 1885. Corrected on a later cover to June 25, 1875
6	21–24	Oct. 25, 1875	21–24	July, 1885. Corrected later to Oct. 25, 1875
7	25–28	Dec. 15, 1875	25–28	Dec. 15, 1875
8	29–32	Dec. 15, 1875	29–32	Dec. 15, 1875
9	33–36	July 1, 1876	33–36	July 1, 1876
10	37–40	July 1, 1876	37–40	July 1, 1876
11	41–44	Dec. 15, 1876	41–44	Dec. 15, 1875 (!)
12	45–48	Dec. 15, 1876	45–48	Dec. 15, 1876
13	49–52	Aug. 15, 1877	49–52	Aug. 15, 1877
14	53–56	Aug. 15, 1877	53–56	Oct. 15, 1878 (!)
15	57–60	Oct. 15, 1878	57–60	Oct. 15, 1878
16	61–64	Oct. 15, 1878	61–64	Oct. 15, 1878
17	65–68	July 20, 1881	65–68	Oct. 15, 1878 (!)
18	69–72	July 20, 1881	69–72	July 1, 1876 (!)
19	73–76	Jan. 28, 1882	73–76	July 1, 1876 (!)
20	77–80	Jan. 28, 1882	77–80	July 1, 1876 (!)

INDEX

N.B.—The names in thick type indicate the species and varieties maintained, and the pages in thick type where they are described, the other pages in ordinary type indicate information concerning them.

EXPLANATION OF PLATES

EXPLANATION OF PLATES

O.S.=Outer surface view. *I.S.*=Inner surface view. The magnification of the illustrations is about 400–500 diameters, unless otherwise specified.

PLATE 1.

1. *Arachnoidiscus sendaicus*, N.E.Br. *O.S.* Valve showing the manner of growth by the secondary rays growing in to the centre and becoming primary rays, as at A, B, C and D, and at E and other parts secondary rays are seen to be elongating. See p. 34.

2 and 3. Reproduction of *Cymbella cistula*. See p. 32.

4. Sporangia of *Amphora cymbifera* ? See p. 31.

5–8. *A. ornatus*, Ehr. Sketches of a mature conjugating frustule with a multiple girdle and of its structure at various magnifications. 5, showing the frustule increased in depth by the successive addition of bands to the girdle. 6, some of the bands much enlarged, showing their structure. 7, view of the girdle-bands in section, *I.S.* indicating the inner surface of the girdle, diagrammatically showing how the flap of each band overlaps the band next above it, but is represented free, while in reality it fits closely upon, and is doubtless cemented to, the back of the band, and can only be seen when the ends of broken girdles are mounted next the cover-glass. 8 represents one of the spots on the flaps of the bands, dotted, as described in the text. See p. 26.

PLATE 1.

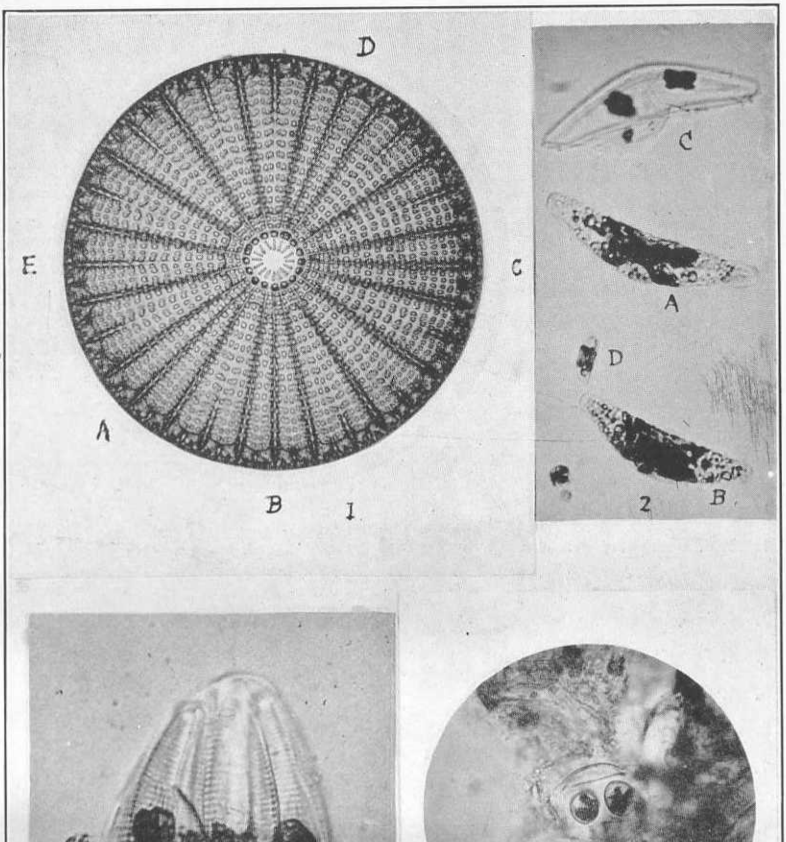


PLATE 2.

This plate is for the purpose of defining the terms used, and is self explanatory, but the species used for illustration are :

1. *A. oamaruensis*, N.E.Br. *O.S.*

2. *A. ornatus*, Ehr. *O.S.*

3. *A. indicus*, Ehr. *O.S.*

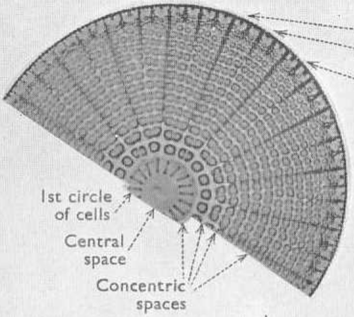
4. *A. Longii*, N.E.Br. *O.S.*

5. *A. Grevilleanus*, Hardm. *O.S.*

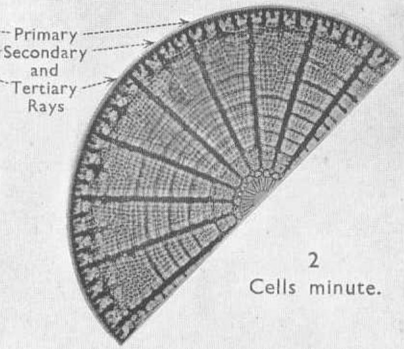
6. *A. oamaruensis*, N.E.Br. *I.S.*

7. A cell of *A. Ehrenbergii*, showing the dotted outer membrane as seen reduced from a magnification of 5,500 diameters.

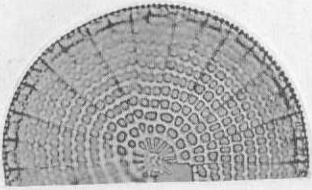
Plate 2.



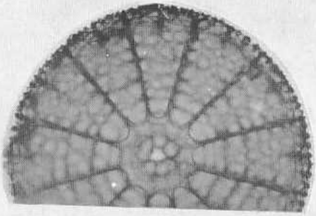
1
Cells large, the rows between the rays opposite at the rays.



2
Cells minute.

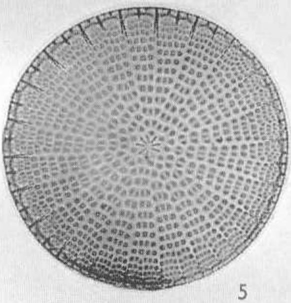


3
Tertiary rays absent; cells large.

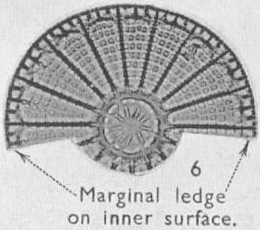


4
Primary rays with a connecting membrane at the centre; cells very large.

Rays black or black-edged of all the above and the cells not sunk in pits.



5
Rays white with black tips; cells small, sunk in pits, the rows alternating at the rays.



6

7 A cell of A Ehrenbergii highly magnified.

PLATE 3.

1. *A. Longii*, N.E.Br. *O.S.*

2–5. *A. ornatus*, Ehr. *O.S.* 2 and 3 represent the type form from Japan ; in 2, the cells of the first circle are cuneate or rounded in form, and the right-hand upper part represents the outer surface at the " white-dot " focus, while the opposing lower part, by the tilt of the valve, represents the focus penetrating to the marginal ledge on the inner surface of the valve. 3 represents an opposing valve in which the cells of the first circle are linear. See p. 18. 4 and 5 represent the Mauritius form, showing the linear and cuneate cells of the first circle of opposing valves, and the other cells are also different in shape and arrangement from those of the type form.

6. *A. spissus*, N.E.Br. Sketch of part of the type, $\times 400$. California.

PLATE 3.

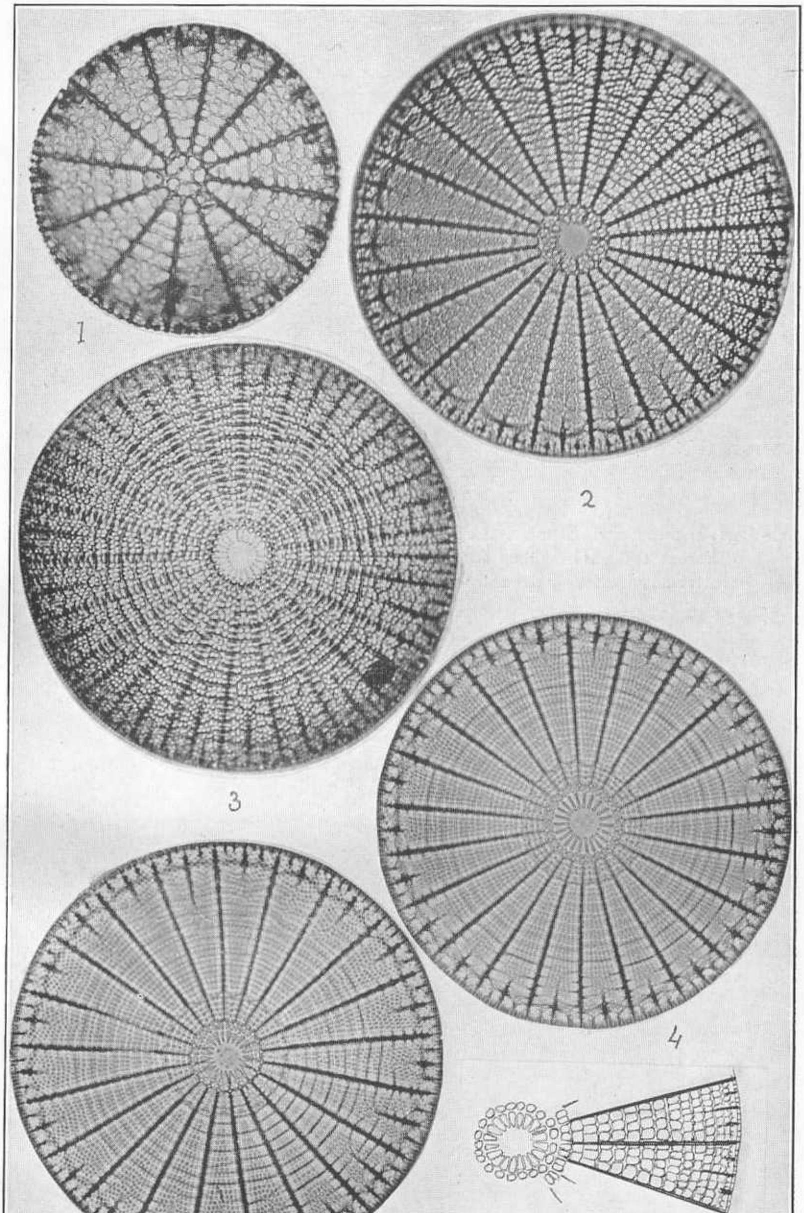


PLATE 4.

1–4. *A. ornatus* var. *dispar*, N.E.Br. 1–3 represent the same valve as seen at different foci, 1 being as seen at the correct focus, but it is very much whiter as seen under the microscope ; 4 represents another valve. Russia.

5. *A. Ehrenbergii*, Bail. *O.S.* Typical form from Port Townsend.

6–8. *A. sendaicus*, N.E.Br. *I.S.* Japan. 6, part of valve as seen with a 1/6th, and 7 and 8 the cells as seen through some of their window-like openings, under a 1/12th objective.

PLATE 4.

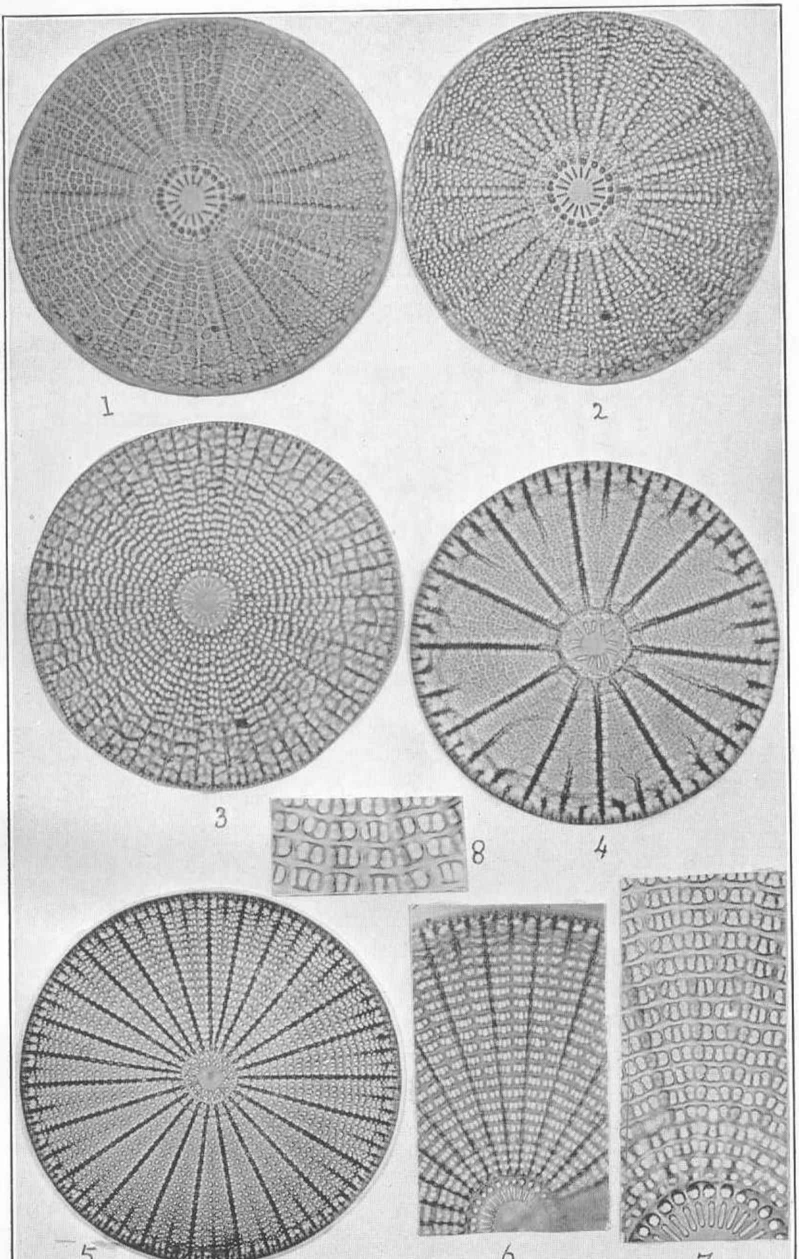


PLATE 5.

1. *A. hybridus*, N.E.Br. Hybrid form between *A. sendaicus*, N.E.Br. and *A. ornatus*, Ehr. *O.S.* Japan.

2 and 3. *A. oamaruensis*, N.E.Br. *O.S.* New Zealand.

4. *A. Adamsii*, N.E.Br. Sketch of the type, $\times 300$. California.

5. *A. deficiens*, N.E.Br. *O.S.* New Zealand.

6. *A. hungaricus*, N.E.Br. *O.S.* Hungary.

7. *A. cognatus*, N.E.Br. Barbados.

8 and 9. *A. indicus*, Ehr. *O.S.* Nancowry (Type locality); 9A represents the contour of the valve in section.

Plate 5.

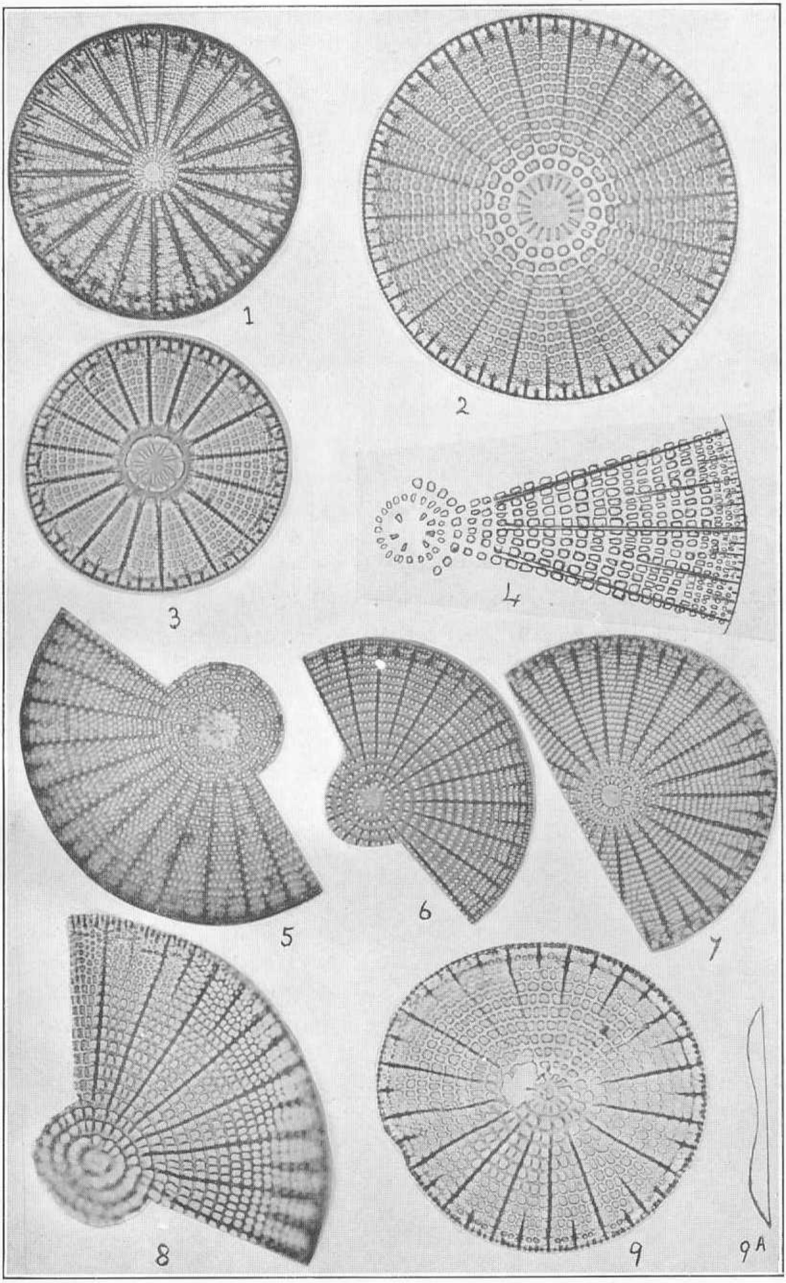


PLATE 6.

1 and 2. *A. clarus*, N.E.Br. *O.S.* Barbados. See note on p. 69. 1A represents the contour view of the valve in section.

3. *A. decorus*, N.E.Br. *I.S.* California.

4 and 5. *A. antarcticus*, N.E.Br. 4, *O.S.*; 5, *I.S.* Antarctic Region.

6. *A. giganteus*, Pant. *I.S.* European Russia.

7. *A. beringensis*, N.E.Br. Behring Sea. Sketch of the type, $\times 300$.

8. *A. Grevilleanus*, Hardm. Barbados.

PLATE 6.

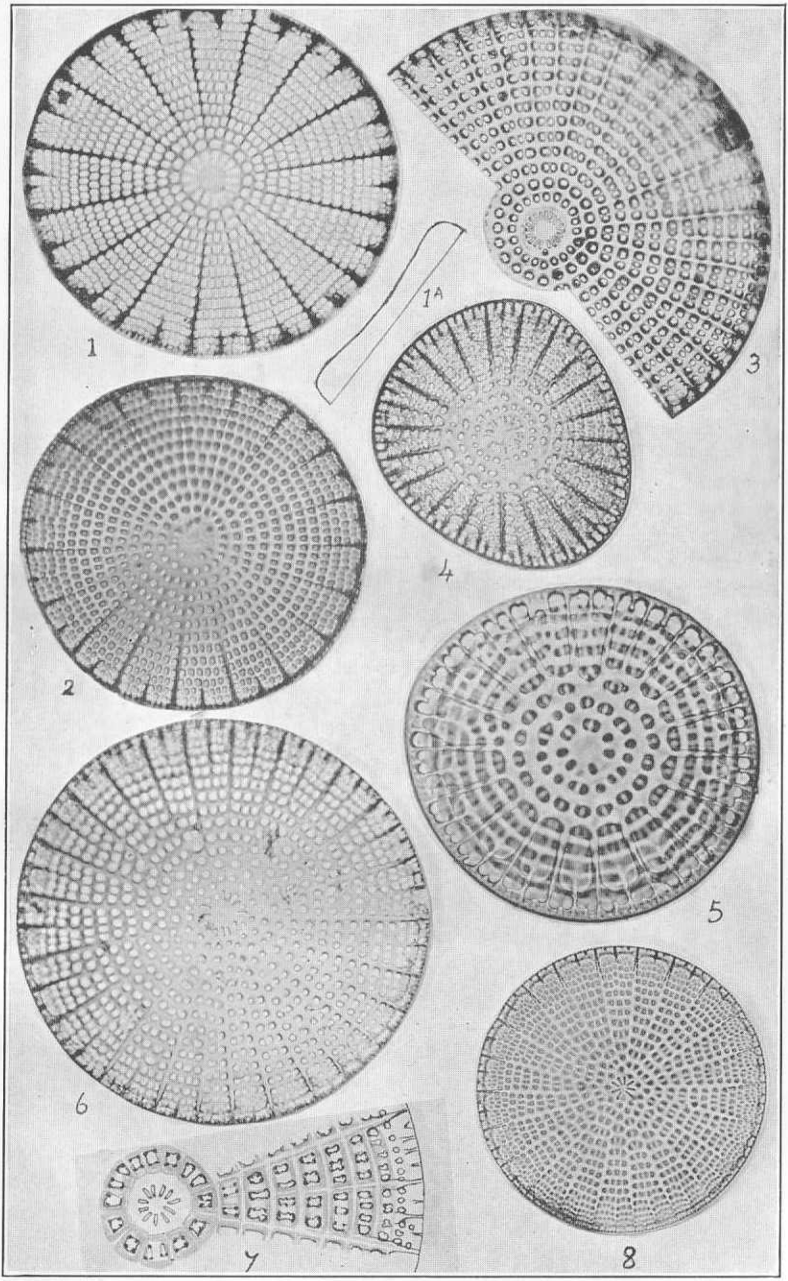


PLATE 7.

This plate represents phases in the life-history of *A. ornatus*, Ehrenb., 1, 2 and 5 being from photographs taken by Mr. E. J. Steer, and 3 and 4 from photographs by Mr. W. N. Ellis. All from specimens mounted by Mrs. E. J. Steer, and at different magnifications. See p. 26.

1. A group of valves, of which the small specimens in the outer circle are males, the remainder being females.

2 and 3. Sporangial capsules attached by a short stalk to the lower valve of the fertilised frustule. The capsule is not siliceous, but in the specimen that has cracked open can be seen indications of the markings upon the siliceous shell of the sporange contained within it, and it will be noticed how very much larger the sporange is than the valve of the mature parent frustule that gave birth to and remains attached to the capsule.

4 and 5. Conjugating frustules.

PLATE 7.