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VII.—*Notes of a Microscopical Examination of the Chalk and Flint of the South-east of England; with remarks on the Animalculites of certain Tertiary and Modern Deposits.* By Gideon Algernon Mantell, Esq., LL.D., F.R.S.*

The founders of this Society could scarcely have imagined that the structure and economy of those minute forms of animal existence which are invisible to the unassisted eye, would become a legitimate subject of geological investigation; and that the durable coverings or cases of these miniatures of life would be found preserved in a fossil state, and in such inconceivable numbers, as to constitute not only a large proportion of many rocks, but the entire mass of certain deposits of great thickness and extent: still less could they have surmised that the soft perishable bodies of animalcules of this kind would be preserved by mineralization, and be found entombed, like flies in amber, in the flint nodules of which our roads are so largely constructed.

When the attention of geologists was first directed, a few years since, to this most interesting department of palæontology, by the surprising discoveries and startling deductions of that eminent philosopher, M. Ehrenberg, several observers in this country entered upon the investigation with much alacrity, to satisfy themselves of the correctness of the marvellous statements of the Prussian naturalist; but this inexhaustible and most inviting field of inquiry has not been followed up with the zeal and assiduity which might have been anticipated, from the facility of the examination, and the important results which could not fail to be obtained by any competent and patient observer.

With the exception of the able "Memoir on the Siliceous Bodies of the Chalk, Greensands and Oolites," by Mr. Bowerbank, and which is published in the sixth vol. of the Geological Transactions,—a memoir to which I shall hereafter have occasion to refer,—no express communication on this subject has, I believe,

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been laid before this Society. My friend the Rev. J. B. Reade (of Stone, Bucks), a gentleman well-known as an eminent observer, was the first to investigate the flints of the English chalk in search of those curious bodies termed *Xanthidia*; several species of which were discovered by him, and are figured and described in the ninth number of the 'Annals of Natural History.' Mr. H. Hopley White subsequently pursued the inquiry, and contributed a notice on flint *Xanthidia* to the first vol. of the 'Microscopical Journal,' illustrated with figures of several new forms.

Many interesting remarks on the microscopical examination of flint and chalk by Mr. Reade are inserted in the fourth edition of my 'Wonders of Geology,' as well as in my recent work, 'The Medals of Creation'; which also contains an account of some discoveries by my assistant Mr. Hamlin Lee, and by my son*.

I propose on the present occasion, to lay before the Society the general results of a microscopical examination of numerous specimens of chalk and flint, from the south-east of England, with the hope of exciting those who have more leisure and greater ability than myself, to pursue the inquiry, and not from an undue estimate of the importance of the facts embodied in this communication.

With a view to conciseness, it will be convenient to arrange my observations under three heads, viz.—

I. On the organic composition of the white chalk.

II. On the organic structure and minute fossil bodies of chalk flints.

III. On the animalculites of the tertiary strata of England; and on the occurrence in the British seas of living genera and species of infusoria, identical with many that occur fossil in the miocene deposits of Virginia.

I. *On the White Chalk.*—Mr. Lonsdale long since demonstrated that the white chalk of England was largely constituted of minute shells, corals, and foraminifera, which bodies might be readily detected by brushing the chalk in water and collecting the sediment; but it was not at that time suspected that almost the whole of the residue of the detritus was composed of distinct organisms, so minute as to require the highest magnifying powers, and a peculiar mode of manipulation, to develope and define. Ehrenberg, who has determined several hundred species of animalculites from the chalk, states that some layers of that limestone are so rich in fossil remains, that a cubic inch is made up of at least one million of recognizable forms. In his memoir "On numerous Animals in the Chalk Formation which are still to be found in a living state," are particularized all the

* See 'Medals of Creation,' vol. i. chap. vii.

species and genera detected in the chalk from various parts of Europe, Asia, and America*. It will suffice for my present purpose to enumerate a few of these fossil organisms, premising that the term *Polythalamia,* or polythalamian animalcules, designates the calcareous-shelled foraminifera, as for example, *Rotalia, Textilaria, Nodosaria,* &c., and that of *Infusoria,* the siliceous-shelled animalcules, as *Xanthidia, Coscinodisci,* &c.; while the name *Animalculites,* is a convenient general designation for the fossil remains of both divisions of these microscopic forms of animal organization.

Infusoria of the Chalk.—M. Ehrenberg describes one species of *Eunotia* and two of *Fragillaria* from Gravesend; and from the chalk marls of Sicily several species of *Actinocyclus, Coscinodiscus,* and *Gaillonella,* which are also found alive in the sea at Cuxhaven. The most remarkable forms are certain species of *Dictyocha,* a genus formerly supposed to be extinct, which abound in the white marls of the chalk of Cattanisetta, and have lately been found living in the Baltic †.

Another interesting animalculite is the *Peridinium pyrophorum,* which occurs in the flint of Delitzsch, and has recently been detected living and luminous in the Baltic.

Numerous species of all the above genera abound also in the tertiary strata, and were formerly supposed to be absent in the secondary formations; and with the exception of a few kinds to be noticed hereafter, my own researches and those of several competent observers have not revealed any traces of these organisms in the English chalk; we have never found *Eunotiæ* or *Fragillariæ* in that of Gravesend. Of the microscopic calcareous-shelled animalcules, the chalk contains species, said by Ehrenberg to be identical with living, of the genera *Globigerina, Rosalina, Cristatella, Textilaria, Rotalia* and *Nodosaria*; and so far as my observations extend, species of these genera form the greater part of the cretaceous animalculites of England. But although it is easy to demonstrate the abundant occurrence of these forms in some masses of chalk, yet in many of the strata it is scarcely possible to detect any well-defined specimens; and I confess, that frequent disappointment in my search for these bodies, had made me somewhat sceptical of receiving at their full value, the glow-

* See a translation of this memoir, with plates, in Taylor's 'Scientific Memoirs,' vol. iii. Art. 13. Also a masterly abstract of Ehrenberg's observations "On the Composition of Chalk Rocks and Marls by invisible organic bodies," by Mr. Weaver in the 'Annals of Nat. Hist.' for June and July 1841.

† The *Dictyochæ* are polygastric animalcules of the family *Bacillaria,* which are invariably coloured by green granules, and have a slow creeping motion.

ing descriptions of the Prussian philosopher. A short time since, however, I discovered some layers of chalk which are wholly composed of polythalamia, principally of the genera *Rotalia* and *Textilaria*; and it may perhaps be interesting to other observers if I mention the circumstances which led me to institute a microscopical examination of these deposits.

Every one knows that in our white chalk corals are but sparingly distributed, and that the species hitherto determined are comparatively few. Those enumerated in Mr. Morris's 'Catalogue of British Fossils' amount to between twenty and thirty species, and belong to sixteen or seventeen genera. The cretaceous deposits of Maestricht and Faxoe present in this respect a striking contrast with those of England. There are however a few localities in which certain layers of the chalk abound in small, delicate, calcareous polypidoms; and of late years many beautiful specimens of the genera *Idmonea, Ceriopora, Pustulopora, Retepora,* &c. have been obtained from the neighbourhood of Dover. For the most part the specimens are small, but occasionally some occur of considerable size, as in the fine example on the table (presented to me by Mrs. Smith of Tunbridge Wells), which consists of hundreds of branches of *Pustulopora* and *Idmonea,* intertwined into a mass more than two inches in thickness. When clearing this beautiful fossil, the extremely friable nature of the chalk, and the sensation of a peculiar asperity to the touch, which experience had taught me was commonly characteristic of the presence of minute fossil bodies, induced me to submit a few grains to a microscopical survey; and the entire block of chalk in which the coral is imbedded, proved to be almost wholly constituted of *Rotaliæ* and *Textilariæ,* associated with spines of sponges and of other Amorphozoa, and a few discs apparently of *Pyxidicula*: the residue consists of the detritus of similar organisms and of polyparia. I have distributed samples of this coralline chalk among my friends, and the result of their exploration is in accordance with my own.

The incoherent character of the Dover coralline chalk, results therefore from its organic composition, and the absence of any cementing material. For in other cretaceous strata where an infiltration of calc-spar has consolidated the rock, the chalk possesses great compactness and durability, and the organisms may be seen in polished slices, and sometimes in relief on the surface. That the white chalk was originally everywhere of the same organic constitution there can be no reasonable doubt; and it is remarkable how universal was the distribution of certain species throughout the cretaceous ocean. The *Rotalia globulosa, Rot. perforata,* and *Textilaria globulosa,* have been found in every chalk district in Europe; and I have the same species, through the kindness of Dr. Bailey of West Point, New York, from various parts of Asia and America.

I will now venture to digress for a brief space to inquire whether the original organic incoherent condition of the chalk, as shown by the above investigations, may not offer a satisfactory explanation of the formation of the grooves and furrows on the surface of chalk rocks, and of the vertical funnels or sand-pipes with which in certain districts the cretaceous strata are traversed; and of the origin of the beds of loose, but not water-worn, flint nodules, which are so constantly met with lying on the surface of the rock, and immediately beneath the turf of the downs, and with scarcely any intermixture of transported materials; phænomena, that have very recently been brought under the notice of this Society. From what has been advanced, it is manifest that the chalk when first deposited at the bottom of the ocean must have been in the state of a fine white detritus or mud, resembling in appearance and in chemical and organic composition, the chalk now in progress of formation along the coasts of the Bermuda Islands; some layers of which are as rich in animalculites as any of the American tertiary formations. The veins and beds of flint, probably originated from the periodical introduction of thermal waters highly charged with silica, into the calcareous sediment: and the subsequent conversion of the incoherent detritus into compact white chalk, must have resulted in part from pressure, and from the infiltration of crystallized carbonate of lime; a process which at the present moment is in constant action on the shores of the Bermudas, and whose effects are seen in the specimens on the table, in which the sediment thrown down by the sea is shown in various states, from that of a white pulverulent earth, to the compact limestone with which the forts and bridges of those islands are constructed.

It may, therefore, with great probability be assumed, that at the period when the cretaceous strata of the south-east of England were exposed to those elevatory movements which ultimately raised them, together with the Wealden deposits on which they repose, above the level of the sea, the lowermost beds of chalk were already consolidated; but the uppermost and latest deposits were in the state of the soft Bermuda earth. Upon the emergence of the chalk above the sea, those last formed and consequently least coherent beds, would be the first exposed to the destructive effects of the waves; and if the elevation were gradual, successive strata would be subjected to the same agency, until the chalk-hills were lifted up above the operation of these denuding causes. The drainage of the elevated portions of the soft calcareous rock would then commence, and give rise to numerous streams and rills, by which the surface would be worn into furrows and channels; and funnels (sand-pipes) would be formed by the gyratory action of eddies, or whirlpools, induced by opposing currents; effects in every respect analogous to those observable on the mud-banks of a delta, during the recession of the tide. The beds of loose, unrolled, and but slightly abraded flints, the smooth rounded contour of the gently swelling hills and undulated coombs and valleys of chalk districts, appear to me to be the natural consequences of the phænomena here contemplated.

II. *Chalk Flints.*—I now proceed to the consideration of the organic structures, and microscopical fossil bodies, observable in chalk flints. It was a current opinion with Parkinson, Townsend, M. Guettard, and other early observers, that the external forms of a large proportion of the flint nodules had been derived from various kinds of sponges and alcyonia, which, while growing in their native sea, or floating in its waters, had become enveloped and saturated by the fluid silex; and it was also inferred that these organisms had served as points of attraction for the siliceous matter, and were in a great measure the cause of the irregular nodular character, and mode of distribution, of the flints of the cretaceous formation. The occurrence of minute shells, corals, and other organic remains in the flints, was adduced as additional confirmation of this opinion; since a similar entanglement of foreign bodies in the hollows and meshes of recent sponges is constantly observable. My much-valued friend the late Mr. Parkinson, investigated this subject with his wonted ability and caution, and many interesting observations on fossil sponges, illustrated by excellent figures, will be found in the second volume of the 'Organic Remains of a Former World.' That various kinds of *Porifera* or *Amorphozoa* have formed the nuclei of immense numbers of the flint nodules, will be readily admitted by all who have paid but a moderate share of attention to the subject; and the prevalence of spicula of sponges in chalk and flint, proves the abundance of these organisms in the cretaceous seas. The microscopical examination of flint corroborates this inference, for the brown reticulated *tissue,* so general in siliceous nodules, is unquestionably referable to certain kinds of sponges. This fact Mr. Bowerbank has satisfactorily established in the valuable memoir previously cited; a memoir which presents so admirable an illustration of the nature of the spongeous structure observable in chalk flints, and in the agates of Oberstein, and in the green jasper of India, and such clear and ample directions for the successful investigation of these organic remains, as to render but few remarks on the subject necessary. I will only state that my own observations confirm those recorded by Mr. Bowerbank in every essential particular; namely, in the frequency of the reticulated spongeous tissue, and of spicula, in our flints; in the presence of polythalamia and infusoria, particularly of *Xanthidia*, in the canals of sponges, and their frequent suspension throughout the mass of a siliceous nodule; as if the spongeous tissue had retained its form sufficiently long to allow of the silicification of the animalcules, and had subsequently perished. At the same time I must express my conviction, that the facts he so faithfully portrays do not warrant the hypothesis that all the nodules, veins, dikes, and sheets of flint, are to be ascribed to the silicification of sponges; neither can I admit that the cavities of the shells of echinoderms and mollusks, now found filled with flint, were previously occupied by sponges. The theory of M. Ehrenberg, that the compact nodules of flint are the consolidated pulverulent siliceous particles of infusoria, I conceive to be equally untenable. Nor do the facts hitherto brought before us seem to warrant the inference, that the abundance of siliceous spicula in any of the porifera rendered those bodies more favourable for silicification; on the contrary, the soft gelatinous animal matter, as Mr. Bowerbank has suggested, does appear to have exerted such an influence by some species of elective affinity or attraction: hence the frequent silicification of the bodies of mollusks, while the shell retains its calcareous character, as in the specimen of an oyster figured in the 'Medals of Creation,' p. 363.

In many of the silicified fossils of the chalk, the mineralization is simply that of incrustation and infiltration; such is the state of numerous sponges, which are, as it were, invested by the flint, and have their pores and tubes filled with the same substance; but the spongeous tissue is in the condition of a brown friable earthy substance. In other examples the sponge has been incrusted by a mass of liquid silex, and its tissue has subsequently perished; in this manner have been formed those hollow nodules, which, on being broken, present a large cavity containing only a little white powder, or some loose fragments of silicified sponge; while in other specimens the cavity is lined with quartz and chalcedony, probably introduced by subsequent infiltration through the nodule. It frequently happens that the zoophyte is only partially invested with silex, while the other portion is imbedded in the chalk, and is a friable calcareous substance. The *Choanites* and *Ventriculites* are often found in this condition, and hence the protean forms assumed by the flints that have been moulded in the cavities of these organisms. These specimens appear to demonstrate that the organic bodies became permeated with flint, only when they happened to be exposed to the current or stream of liquid silex, which penetrated such portions of structures, or entered the cavities of such shells, and echinoderms, as were lying at the bottom of the ocean over which it flowed, or were immersed in the calcareous detritus into which the stream was injected. And there are innumerable nodules of flint which exhibit no trace of spongeous structure; as well as veins, dikes, and sheets of tabular flint, that may be regarded as pure, and free from organic remains, excepting such as must necessarily have become entangled and imbedded in a stream of mineral matter flowing over a sea-bottom.

The shells of mollusks, and the crustaceous cases of echinoderms, do not occur silicified in the white chalk, but their cavities are very commonly filled with flint, and these casts are well known as among the most common fossils of the ploughed lands of chalk districts. The phosphate of lime, like the carbonate, seems to have been unfavourable for the phænomenon of silicification. I have seen but two examples of bone imbedded in flint, and in one of these the silex has merely incrusted the bone; in the other, a caudal vertebra of the *Mososaurus* from Brighton, the mineral has partially invested the bone and permeated the cells, but the calcareous tissue remains unchanged. A coprolite of *Macropoma,* partially surrounded by flint, retains its calcareous character; and the teeth of fishes, although sometimes enveloped in flint, are not silicified. I had teeth of the *Hypsodon,* and Mr. Charlesworth has a portion of a jaw with teeth of the *Mososaurus* from the chalk, in which the pulp-cavities are filled with flint, which must have permeated the parietes of the teeth, and yet the calcigerous tubes remain unchanged, and are not filled with silex; here probably the contents of the pulp-cavity influenced the pseudomorphism, as in the case of the oyster.

But in other fossils the mineralization pervades the entire organism, and has been effected by replacement. The original substance has been removed, and the silex substituted in its place; such is the common petrifaction of wood, and of most examples of the softer zoophytes. The *Choanites,* which, from their perfect silicification, are in such request at Brighton for brooches and other ornamental purposes, afford a good illustration of this process.

This complete transmutation of organic structures into flint, quartz, or chalcedony, is very common in other divisions of the chalk formation. In the well-known fossils of the Devonshire whetstone, the shells are almost invariably converted into flint or jasper.

An able American mineralogist, Mr. Dana, suggests* that the reason why silica is so common a material in the constitution of fossilized wood and shells, as well as in pseudomorphic crystals, consists in the ready solution of silex in water at high temperatures under pressure whenever an alkali is present, (as is seen at

* See American Journal of Science for January 1845.

the present time in many volcanic regions,) and its ready deposition again when the waters cool. A solution of silica, whether resulting from the deposition of felspar at the ordinary temperature, or whether proceeding from submarine volcanic action, will in either case contain other substances. The alkali of the felspar, potash, or soda, passes off with the liberated silica; and in the latter case, the heated waters, if marine, will include both soda and magnesian salts. Mr. Dana goes on to show that a mere heated solution of silica in water, under great pressure, is sufficient to explain the phænomenon of silicification of organic structures. Thus in the strata of white chalk, in which the shells of mollusca are not silicified, but remain calcareous, the streams of water holding silex in solution, were probably of a lower temperature than in the case of the Devonshire silicified shells, the pseudomorphism of which may have been effected by a very hot solution of silica. "For a crystal of calc-spar in such a fluid, being exposed to solution from the action of the heated water alone, the silica deposits itself gradually on a reduction of temperature, and takes the place of the lime, atom by atom, as soon as set free. Every silicified fossil is an example of this pseudomorphous process; but there seems to be no union of the silica with the liberated lime, since silicate of lime occurs extremely seldom, if at all, either in the fossils themselves or in the surrounding rock. There appears to be something in the chemical or electro-chemical forces excited among the molecules by the process of solution, which leads the molecules of any body that may be passing at the time from a liquid state to take the place successively of each molecule that is removed; and thus it is that the form of the original structure, to the minutest character, is so exactly assumed by the substituting mineral. Fluor spar, and even heavy spar or barytes, although stated to be insoluble, have evidently undergone solution in heated waters, and thus been deposited in cavities and veins of sedimentary limestones that show no trace of the effects of a higher temperature; for they are not fused, nor even rendered crystalline. The agency of hot waters and vapours in producing changes in rocks and in organic remains has perhaps scarcely received sufficient attention. When we consider the number of hot springs on the surface of the earth in regions of modern volcanic action, as well as in others not of this nature; when we remember the many eruptions of hot water even from subaërial volcanoes; and when further we have before our eyes the wide-spread effects of volcanic action beneath the sea,—can we refuse to the agency of heat thus conveyed by vapours and flowing mineral waters, a large share of the various metamorphic changes in the mineral kingdom; especially if we take into view the condition of a vast submarine volcanic region in full action, with its floods of melted rocks, its opened fissures, and its fountains of boiling waters and jets of heated vapours ?" For a full explanation of these views I refer to the original paper of Mr. Dana in the 'American Journal of Science' for January 1845. The elaborate work of Dr. Blum on the Pseudomorphous Minerals may also be studied with advantage*.

I return from this digression to the consideration of the minute fossils which are of most frequent occurrence in our flints. The polythalamian forms are chiefly referable to the genera *Rotalia, Rotalina* and *Textilaria*; there are also some kinds of the compound foraminifera, but these are comparatively rare, and I have not yet examined them with sufficient attention. In some slices of flint prepared by Mr. Darker from the Paramoudra of Ireland, polythalamia are very numerous. The shells or cases invariably appear to be silicified, and the cells of the *dead* shells to be filled with flint. By *dead* shells I mean those in which the animal was dead, and its soft parts removed and the shell empty, before its immersion in the silex; for I can now bring unequivocal evidence to prove, that in many examples the animal itself must have occupied its shell, and all its soft parts been entire, at the moment when it became enveloped by the siliceous fluid. A specimen figured in the 'Medals of Creation' first directed my attention to this interesting fact; and several specimens both of *Rotaliæ* and *Textilariæ* have since been discovered, which confirm the opinion I then ventured to suggest.

In illustration of this highly interesting fact, I select on the present occasion an atom of flint (scarcely larger than a pin's head) discovered by Mr. Lee, in which are imbedded two *Rotaliæ*, having the cells filled with a rich amber-coloured substance, that under a high power presents a granular structure analogous to that of the body of the recent *Rotaliæ*. In these fossils the soft parts appear to be in the state of *molluskite*, or they may have undergone silicification; the mineral being coloured by the animal matter. To persons unaccustomed to the microscopical exploration of objects of this nature, these specimens may seem to be merely casts of the interior of the shell; but to the eye well-instructed in the character of such remains, they will at once be seen to be entirely dissimilar. I would content myself with referring to the 'Medals of Creation,' in proof of the above inferences, did I not know that many of the Fellows of this learned

* The experiments of Mr. Jeffrys, published in the Report of the British Association for 1840, confirm these opinions, and prove that simply by the agency of heated water and vapour, silex will be dissolved, and be precipitated upon the cooling of the liquid or vapour. In one of these experiments several pounds of silica were deposited on substances placed within reach of the current of vapour.

Society do not read works of so unpretending a character, and may consider this statement as startling and unsatisfactory; I therefore claim the indulgence of entering upon a few details to render the above remarks more intelligible.

It must be borne in mind that the case or shell of the *Rotalia,* although presenting the general form, and the internal chambered structure, of the shell of the *Nautilus,* is essentially different; for the whole of the external case is perforated with numerous holes or foramina (hence the name *Foraminifera*), designed for the passage of delicate processes called *pseudopodia,* which are organs of motion; and the cells or chambers are dissimilar in form, and still more so in their office, from those of the Cephalopoda. For while in the *Nautilus* the animal occupies only the outer chamber, and all the posterior compartments are successively-quitted empty dwellings, in the *Rotalia* the body distinctly fills up all the single cells. According to Ehrenberg, the first four cells in the living animal are occupied by colourless matter; the hinder ones are filled with less transparent parts, consisting of two differently coloured organs. One of these is the very thick alimentary canal, which forms, like the whole body, a jointed chain expanded in each chamber of the shell, and connected by a narrow isthmus (the sipho ?) with the adjoining anterior and posterior ones.

M. Ehrenberg dissolved the shell of a living polythalamian, nearly allied to the *Rotalia* (the *Nonionina germanica*), by immersion in weak hydrochloric acid, and thus exposed the alimentary canal, which was then seen to be a simple organ distended in the compartments of the body, consequently itself articulated with a single anterior aperture; and various siliceous infusoria were distinctly perceived in the digestive tube, having been swallowed by the animal. Beside the alimentary canal, a yellowish brown or amber-coloured granular mass was perceptible in each of the cells, up to the last of the spirals, the first excepted.

It was the striking resemblance between the specimen first submitted to my notice, and the figure of the *Nonionina* deprived of its shell, as given by Ehrenberg, that led me to suspect the true nature of the fossils under review; and the exquisite example which will be placed under the microscope for the inspection of those present, appears to me to leave no doubt of the correctness of that opinion. In the same chip of flint there is another and larger Rotalia, in which the body of the animal also is preserved. And now that we are accustomed to the microscopical appearance of these organisms, we find that the pale yellowish brown, or amber colour, of many semidiaphanous flints is derived from the soft parts of *Rotaliæ, Textilariæ,* and other polythalamian animalcules; in like manner, as I showed in a paper read before this Society (but not published), the dark veins and markings in the pillars of Purbeck marble in the Temple Church, are attributable to the remains of the soft bodies of the freshwater shells of which that limestone is composed, in the state of *molluskite*.

I have stated my conviction that the experienced microscopical observer will not hesitate to agree with me in the opinion, that in the fossils before us we have the mineralized soft bodies of polythalamia; and I have obtained, through the kindness of Mr. Williamson of Manchester, a recent object for comparison, which is perfectly analogous, not to say identical, with the best-preserved flint specimen. It is the body of a Rotalia from which the shell is removed, and is associated with other polythalamia, &c.; it was obtained with numerous other interesting recent organisms in sediment from the Levant.

Infusoria in Flint:—*Xanthidia*.—Our flints contain abundance of several kinds of infusoria; as for example, various species of the genera *Pyxidicula, Peridinium* and *Xanthidium*. I shall restrict my remarks to the last-named animalculites, which, from their elegant forms and good state of preservation, are highly interesting to microscopic observers. The *Xanthidia* are minute, globular or spherical bodies (from $\frac{1}{300}$th to $\frac{1}{500}$th of an inch in diameter), beset with tubular processes, which terminate either in fimbriated or acuminated extremities. They are stated by Ehrenberg to be siliceous, and to be analogous, and some of the species identical, with living forms which abound in boggy pools and ponds. Several of the recent kinds occur in the ponds on Clapham Common, Hampstead Heath, and other places around London. These organisms are however considered by the most eminent botanists not to belong to the animal kingdom, but to be vegetable structures, related to the *Desmidiaceæ*; and are defined as plants having "fronds simple, constricted in the middle; segments slightly compressed, turgid, reniform or orbicular and entire; their surfaces more or less furnished with simple or branched elongated spines, either scattered over the surface or confined to the margin, where they are placed in two rows, one on each side the marginal line*." Ehrenberg, on the other hand, describes the *Xanthidia* as animals having spontaneous motion and increasing by self-division. But I must not dwell on this important and difficult question; the arguments on both sides are concisely stated in 'Annals of Nat. Hist.' March 1845, p. 188, to which I would refer those who are interested in the subject. I do not presume to think that my opinion on this problem is of any value; but waving the question of the animal or vegetable

* See Mr. Ralfs's paper on the *Desmidiaceæ*, Ann. Nat. Hist. Jan. 1845.

nature of these bodies, I may be permitted to state, that a careful examination of both recent and fossil *Xanthidia* leads me to doubt whether there is any analogy whatever between the organisms in our flints and their supposed living types. The fossil forms have the body more decidedly spherical or globular, their spines more strictly tubular and differently arranged; and they never exhibit that reniform or constricted character so constant in the recent *Xanthidia,* nor do they present any indication of spontaneous fissuration. The fossils are supposed by Ehrenberg to have been originally siliceous like the shields of other infusoria, but I know not that any proof has been obtained of this inference. On the contrary, so many examples occur in which the tubular arms are bent, contorted, and contracted and shrivelled in the middle, as to convey the idea of a flexible, rather than of a brittle, unyielding substance. A crushed or torn specimen very lately found by my son, exhibits an appearance much at variance with the supposition that the original was composed of silex or of any other material that had a conchoidal fracture. If the *Xanthidia* were originally siliceous, there is no reason why they should not be detected in the chalk itself, since bodies equally minute are readily discoverable*. If to these arguments be added the *à-priori* objection as to the probability that inhabitants of fresh water, of boggy pools and ponds, should be found swarming in the sponges and other marine structures of the cretaceous ocean, I think in the present state of our knowledge it will be proper, notwithstanding the high authority from which we must differ, to consider the so-called *Xanthidia* of the chalk as distinct from the recent organisms after which they have been named; in fact, as a genus of marine infusoria, should they not hereafter prove to be the gemmules of polyparia or the spores of marine plants.

I will conclude this imperfect notice of the flint animalculites, by stating that several kinds of disciform bodies of great beauty have recently been detected by Mr. Lee; these appear to be transverse sections of different species of the foraminifera termed *Nodosaria,* or of some allied genus.

III. *Tertiary Animalculites.*—I now arrive at the last division of the present inquiry, which will comprise a few remarks on the occurrence of animalculites in the tertiary strata of Great Britain; and of living species and genera of infusoria in the British seas, analogous to those of the miocene deposits of North America.

The organic constitution of the tertiary marls of Virginia, and the nature of the fossils of which they are composed, are too well

* Since the above remarks were written, numerous *Xanthidia* have been detected in chalk from Dover by Mr. Henry Deane of Clapham; but the appearance of these specimens, when cleared from the chalk and mounted in Canada balsam, seems to support the opinion that the originals were flexible and not siliceous.

known to require particular description. They are almost entirely made up of the aggregated siliceous cases or skeletons of infusorial animalcules; the prevailing forms belonging to the genera *Coscinodiscus* (sieve-like disc), *Actinocyclus* (wheel-like disc), *Dictyocha, Gaillonella, Pyxidicula,* and numerous kinds of the family of *Bacillaria*. Figures and descriptions of many of these fossils by Dr. Bailey will be found in several of the late numbers of the 'American Journal of Science.' The most remarkable of the siliceous shields are the orbicular cases of the *Coscinodisci,* which, when entire, consist of a pair of discs, connected at the periphery by a broad band or ring. The delicate and elegant markings with which the surfaces of these shields are elaborately sculptured, render them objects of great beauty and interest. An assemblage of these tertiary animalculites presents so striking a contrast to any I have seen from the chalk of England, Asia, or America, that I am very desirous M. Ehrenberg's statement as to their prevalence in cretaceous strata should be verified by further investigations; and the more so, as Dr. Bailey mentions that Ehrenberg referred certain unquestionably miocene American deposits to the chalk, because they yielded animalculites resembling some he had obtained from European strata supposed to belong to the Chalk formation.

I have sought in vain among the tertiary strata of England for infusorial deposits analogous to those of America. Polythalamia frequently occur in the London clay (as was first made known by Mr. Wetherell in a valuable paper published in our Transactions); and within the last few weeks several kinds of foraminifera have been obtained from clay brought up in sinking a well at Clapham, at the depth of 120 feet. But no one has discovered in our tertiary formations a bed, or even seam of earth, composed of fossil infusoria. In fact, so far as my information extends, our only rich deposits of this kind are of very recent origin. Near the banks of the river Bann, in the county of Down, Ireland, there is a layer of infusorial earth a foot thick, underlying a bed of peat. Specimens of this earth, with which I have been favoured by the Countess of Caledon, accompanied with drawings by her ladyship of the prevailing organisms, show that the bed consists of an aggregation of the siliceous shields or cases of numerous kinds of *Bacillaria,* but no traces of *Coscinodisci* or other usual American tertiary species occur; this arises probably from the Irish deposit being of fluviatile origin*.

* It may be added, that the property of polishing metal, which deposits of this kind are so well known in Germany to possess, has been discovered by the Irish; and as this earth occurs on the estate of Lord Roden at Tulleymore, it is locally known as Lord Roden's plate-powder.

Some white earth recently sent from New Zealand as magnesia, proves to be a fluviatile infusorial deposit like that of Ireland.

But if I have hitherto been unsuccessful in the microscopical exploration of our tertiary strata, an unexpected assemblage of the American miocene forms has been found in the digestive organs of certain living mollusca. Mr. Lee's discovery of recent *Coscinodisci* in the barnacle (announced in the 'Medals of Creation') has been followed up by his detection of numerous species and genera of infusoria in the stomach of the common scallop (*Pecten maximus**). These recent animalcules present almost all the genera and some of the species that prevail in the tertiary marls of Virginia; in particular two very striking and abundant fossils of the Richmond earth, the elegant *Coscinodiscus radiatus* and the *Dictyocha fibula*. So close is the analogy, not only of the individual shields, but even of their collocation, that it would be difficult for an experienced observer to distinguish slides mounted with the respective organisms, although the one group is from deposits of unfathomable antiquity, and the other from the British seas.

I have already stated that the modern calcareous deposits of the Bermuda Islands contain layers of infusorial earth; these are made up of organisms resembling those of America and the recent species found in the scallop.

One more fact in connexion with this subject remains to be mentioned. Along the shore of the Sussex coast to the east of Brighton, a bed of sand and calcareous mud, the detritus of the neighbouring cliffs, is in the progress of formation; and in this sedimentary deposit my son, Reginald Neville Mantell, has discovered shells of recent *Rotaliæ*, *Nodosariæ*, and other polythalamia, associated with the siliceous shields of *Coscinodisci*, *Dictyochæ*, and other infusoria, and with *fossil Rotaliæ and Textilariæ from the chalk*. Here then at the present moment a deposit is in progress, whose organic contents consist of an assemblage of the living species of the animalcules of the present sea with the fossil forms of the ancient chalk ocean; in like manner in the bed of the Nile, the polythalamia of the Nummulite rock are being imbedded with the existing mollusca of that river: collocations of this nature may perhaps exercise the ingenuity of the geologists of future times, and give rise to speculations of as little value as some of those with which I have ventured to trespass on the indulgence of the Society.

In conclusion I would remark, that the preceding observations are the result of the examination of organisms within the reach of the best microscopes which modern art has produced; yet there can be no doubt, that if the powers of our instruments could be increased, fossil structures yet more minute and far

* See Annals of Nat. Hist. April 1845.

more abundant would be detected. And if the naturalist be allowed to assume, that in the existing creation, "within and beneath all that minuteness which the aided eye of man is able to explore, there may be a world of invisible beings; and that could we draw aside the mysterious curtain which shrouds them from our senses, we should behold a theatre of as many wonders as astronomy can unfold,—a universe within the compass of a point so small as to elude all the powers of the microscope,"—surely the geologist may be permitted to conclude, that a large proportion of the sedimentary strata, which at present appears to consist of amorphous particles of lime, of flint, and of iron, may be the aggregated skeletons of beings yet more infinitesimal than those which have formed the subject of the present communication.

19 Chester Square, Pimlico, May 1845.

VIII.—*On the Occurrence of an Intestinal Worm in an Acaleph.* By M. Sars*.

[With a Plate.]

In Wiegmann's Archiv,' vol. ii. p. 322, 1841 (Annals, vol. iii. p. 148), it is stated that a parasitical worm resembling a *Filaria* had been discovered by Prof. E. Forbes in a species of *Cydippe*, and subsequently (vol. ii. p. 370, 1842), that this parasite, which attaches itself by means of four suckers to the walls of the stomach or vessels, had been described by Messrs. Forbes and Goodsir under the name of *Tetrastoma Playfairii*. The reporter adds, that further observation would be of interest, as hitherto no intestinal worms had been met with in the *Medusæ*.

The reporter had forgotten that the discovery of an intestinal worm in an Acaleph had been published by me already in the year 1837. (See Ann. des Sci. Nat. 1837, vol. vii. p. 247.)

It is not to claim any priority as to this discovery, which is a matter of perfect indifference to science, that I return to this subject, but merely to communicate the following short notices written down in 1835, which I have hitherto kept back on account of their imperfect state, in the hope, unfortunately hitherto delusive, of completing them by further observations.

It was on a gigantic individual of my *Mnemia norwegica*, five inches in length, which I caught on the 4th of November 1835, near the island Floröe, that I observed, within the transparent clear body, from ten to twelve longish opake white bodies of about a line in length, which proved, on closer examination, to be intes-

* Translated from Wiegmann's Archiv, 1845, part 1.