G. S. xxxix. tab. iii. fig. 6). Not common in the Lower Argovian beds.

11. Test fixed, more or less cylindrical, small, bearing a small number of short papillæ regularly disposed round the margin of the chamber. Cement hyaline. Rare, in the Upper Jurassic sponge-beds (fig. 28, and Neues Jahrb. 1883, tab. iv. fig. 12).

Brady mentions an interesting polythalamous form, two or three chambers being adherent to each other. I have not been able to find similar specimens in the Jurassic beds; but it is possible that they occur, especially in the sponge-beds, with numerous spherical varieties, but that the single chambers are broken off during the preparation. As an interesting fact, we must mention that several specimens were found with a second interior chamber, similar to those described by Brady.

Trusting that these few remarks on a very important but still little known arenaceous form may give new proofs of the continuity of certain species and of the great variety of Foraminifera, I must express my thanks to all the gentlemen who have assisted me by sending specimens for comparison, washings from Jurassic rocks, samples of limestones, and notes on the occurrence and different varieties of *T. papillata*.

XXXVI.—*Investigations upon some Protozoa.*

By Dr. August Gruber*.

[Plate XIII.]

The present memoir consists of several sections which stand in no direct connexion with each other, and extend over various regions of Protozoology. The first part is devoted to the description of some new Rhizopods, which will be found interesting in several respects; in the second some Infusoria, partly new, partly not well known, will be described; and the last section will treat of some peculiar phenomena of union in Heliozoa.

Besides the observation of the living animal, I have availed myself of the mode of preparation described by Korschelt †,

* Translated by W. S. Dallas, F.L.S., from the 'Zeitschrift für wissenschaftliche Zoologie,' Bd. xxxviii. pp. 45–70.

† "Ueber eine neue Methode zur Konservirung von Infusorien und Amöben," Zool. Anzeig. no. 109.

which has done me excellent service. This, as is well known, consists in killing the animals quickly by means of a reagent which is allowed to flow under the covering-glass, and which at the same time hardens them, after which, while still under the glass cover, they may be stained, deprived of water, and mounted in Canada balsam. For killing the animals Korschelt employed chromic acid; but other reagents which produce a rapid stiffening will serve equally well, such, for example, as absolute alcohol, hot solution of corrosive sublimate, and osmic acid. Landsberg* has recently recommended another method, namely the isolation of the Protozoans by means of a pipette, which is certainly preferable when we have to do only with the making of neat preparations for a collection, but of course cannot be employed in all those cases in which the object under treatment must be preserved *in situ* and at a particular moment, or when it is so small that it could not be detected in a watch-glass by means of low powers.

I. New Rhizopoda.

1. *Pachymyxa hystrix.*

I had long ago observed, in the coating formed by Diatoms, Oscillariæ, and other low plants on the walls of our small marine aquarium [at Freiburg i. B.], certain peculiar roundish bodies, which I at first regarded as the fæces of some worm or crustacean. On closer examination, however, there appeared to be too great a regularity in their formation, and especially in their external covering; so that I was led to suppose that these bodies were independent organisms; but of what kind I was quite uncertain, as no motory phenomena seemed to be observable. After many fruitless endeavours, however, I at last succeeded, by leaving the bodies in question for a long time undisturbed under the glass cover, in arriving at a conclusion as to their nature and ascertaining that I had before me Rhizopods, certainly of very peculiar organization.

I have not been able to discover in literature any species agreeing with this form, and must therefore create a new name for it. This will be an expression of the bodily constitution of the Rhizopod, namely *Pachymyxa hystrix.*

To the naked eye the larger examples of *Pachymyxa* appear as small white granules, which stand out very distinctly from a dark ground. In the coat of algæ growing in the aquarium

* "Ueber Konservirung von Protozoen," Zool. Anzeiger, no. 144.

we often find whole layers of light points, which are due to such Rhizopods. One of the large specimens that have come under my observation measured 0·6 millim. in length, with a breadth of 0·3 millim.; while, on the other hand, *Pachymyxæ* may very often be met with of a globular form and not more than 0·09 millim. in diameter. When a specimen is placed under the microscope and examined by transmitted light, it no longer appears white, but brownish.

What makes its appearance in the first place is nothing but an envelope which surrounds the protoplasmic body of the Rhizopod. This envelope consists of a layer of closely approximated fine bacilli, which stand about perpendicularly to the surface of the protoplasmic body; they form a sort of felt, or, more properly, a completely closed spiny coat. I have not succeeded in ascertaining of what substance these spines consist. In chromic acid they dissolve immediately, while they remain entirely unaltered on the addition of osmic acid, for which reason the latter reagent was always employed when it was intended to make a permanent preparation.

I had a notion that the spines might consist of carbonate of lime, but could not succeed in confirming this supposition by means of reagents.

This much, however, is certain, that the bacilli are not foreign bodies collected and fitted together, but are a product of the protoplasm itself. On examining the surface, we find that the coating is not completely closed, as it at first appears, but that in many places the bacilli separate and leave gaps between them. These are circular apertures, pretty regularly distributed, which perforate the envelope. In fig. 1 the bacilli on the surface appear depressed and somewhat displaced by the pressure of the glass cover, whilst at the periphery they show themselves in their regular position. It might be expected that the pores would appear as gaps at the margin; but this is not the case, because here the pore is not sharply limited, on account of the bacilli lying beneath it.

These pores are seen both in the living animal and in the empty envelope and the osmic acid preparation. They first led me to the supposition that in these little masses I had before me a Rhizopod which, perhaps, like a Foraminifer, could emit pseudopodia through the pores of its envelope. But the vital phenomena of *Pachymyxa* are so sluggish that the animals when taken from the aquarium and placed on the object-slide usually remain motionless in their envelope.

I was already beginning to regard any further investigations with despair, when, to my delight, I met with a specimen from which a number of pseudopodia radiated (fig. 1).

As I supposed, they issued from the pores of the envelope, although this could not always be demonstrated with certainty. In the figure, which is drawn from life, the pseudopodia are seen only at the periphery; and this is generally the case, either because we cannot detect the pseudopodia issuing from the upper surface, or because the overlying covering-glass here stands in the way of an issue of the sarcode.

As regards the form of the pseudopodia, it is such as to indicate for *Pachymyxa* a position among the Lobosa. It differs, however, from the ordinary form in that the pseudopodia are not lobate often-changing processes of protoplasm, but threads of uniform thickness from the base (*i. e.* from their point of issue) to the tip, and never exceeding a certain length, which can bend slowly to and fro. They most resemble those of *Orbulinella smaragdea* described by Entz *, as this is reproduced by Bütschli in 'Bronn's Klassen und Ordnungen des Thierreichs' (Protozoen, Taf. iv. fig. 4). In this also the pseudopodia issue from pores of the shell †.

I have never observed any branching in the pseudopodia. Usually they are all of equal thickness; and only occasionally, when the animal flattened itself, were broader processes seen to issue from some points. No protoplasmic flow is observable in the pseudopodia; and they consist of perfectly hyaline sarcode without any granules. They appear not to be organs of locomotion; for I have never observed that the *Pachymyxa* effected any change of place by their means. The processes evidently serve only to collect and convey to the body nutritive materials.

Unfortunately I have never succeeded in seeing the *Pachymyxa* take nourishment, and consequently can offer no explanation of the fact that one sees in its interior food-balls which are much too large to be incepted through the apertures of the envelope. It is quite possible that substances originally finely divided are afterwards balled together in the interior of the Rhizopod into such masses.

As regards the protoplasmic body itself, this, even in the living animal, shimmers through the envelope; and its contour is seen to reach to the bacilli. At the points where pseudopodia issue the strong refractive power betrays a layer of hyaline protoplasm, from which the processes are produced, whilst within the body consists of a turbid sarcode abundantly furnished with granules and vacuoles. It is likewise frequently quite full of dark brown food-balls. The whole mass is exceedingly tenacious and dense, so that scarcely any thing

* Naturh. Hefte des ungar. Nat.-Mus. i.

† Entz's memoir has unfortunately not been accessible to me.

of a flow or movement is to be observed in its interior. Nevertheless, when observed for a long time, distinct, although slow, changes of form, in which the spiny part shares, make their appearance. For example, the Rhizopod acquires a band-like form instead of being globular as before; and thus it appears to increase in length under the eye of the observer. In this way it frequently extends itself so much that the bacilli become more widely separated from each other; and thus the view of the interior becomes freer. Such specimens are particularly well adapted for the study of the issue of the pseudopodia from the pores.

In figure 2 I have represented a *Pachymyxa* which has rolled the middle part of its body into a spiral form, having been at first globular and then band-like. We distinctly see the folds which the envelope makes over the tough protoplasm. Soon after the animal had acquired this form it suddenly unrolled itself again, and then slowly regained a rounded form.

But we obtain a better knowledge of the structure of *Pachymyxa* and of the relations of the protoplasm to the envelope than from the living animal by making preparations in which the animals, after being killed with osmic acid, are stained with a solution of carmine and finally mounted in Canada balsam. In the first place, we find that in this process the bacillar envelope is separated as a whole from the protoplasmic body, or the latter contracts from it. From this we see that, although during life this envelope is so closely united with the sarcode that it has to accompany it in all its movements, the bacilli are nevertheless seated upon a special excessively thin outer layer, somewhat like a cuticle, which, however, in life does not separate from the rest of the protoplasm. I have obtained preparations in which this fine membrane had actually become dark-coloured, and thus became very distinctly visible.

At the points where the pores are situated there must of course be a gap in this outermost layer of protoplasm; *i. e.* it is no doubt perforated by each pseudopodium that issues forth, to be formed afresh as soon as the pseudopodium is again retracted. We cannot generally succeed in obtaining a preparation with extended pseudopodia; but on some few occasions I have managed this; and the conditions were particularly distinct so long as the *Pachymyxa* continued lying in the staining-fluid, and therefore before the alcohol had exerted its contractive influence. Figure 3 is drawn from such a preparation. We see in it the bacilli of the envelope far removed from the body and a pseudopodium issuing through a pore. We further see at this point the layer of hyaline protoplasm

which, as already mentioned, always occurs where pseudopodia are formed. This has been more strongly coloured by the carmine than the underlying mass of granular sarcode. Scattered through the latter we observe a great number of granules or spherules, also dark-coloured, upon which I must here give some more details.

In all the *Pachymyxæ* that I have examined (and there were a great number of them) I have never been able to observe any trace of a nucleus; but, under the right treatment, the above-mentioned red points, relieved by their darker colour from their surroundings, nearly always made their appearance. Now it seems not improbable that the red granules represent small nuclei, as, indeed, we meet with a multiplicity of nuclei in other Rhizopods, in *Pelomyxa* for example. In favour of their nuclear nature we have likewise the behaviour of the granules towards reagents, and especially their rapid staining by carmine; this, however, is not a certain proof; and, unfortunately, I am unable to offer any such.

In what relation these possible nuclei stand to reproduction I could not ascertain; but one preparation led me to suppose that they might perhaps give origin to an endogenous division, or, more properly speaking, to a formation of swarmers. Thus in a *Pachymyxa* treated as above described, but in which the protoplasmic body had only become very slightly stained, I met with a considerable number of dark red granules. All these, however, were surrounded by a zone of hyaline protoplasm, also very strongly stained, so that they appeared like small *Amœbæ*. They lay scattered in the sarcode, just like the cells formed internally during the segmentation of the ova of many insects * (e. g. *Gryllotalpa*).

I could never observe the issue of such corpuscles from a *Pachymyxa*; but in my preparations I have often found among the Algæ very numerous little amœbiform creatures of exactly similar structure, which might perhaps be related to them.

But even if a reproduction of *Pachymyxa* by swarm-buds should actually occur, this is not its only mode of propagation; for an increase by division certainly also takes place. We often find specimens which are in process of breaking up into two parts by a constriction taking place in the middle, as indeed might be expected *à priori*†.

Finally, as regards the position of *Pachymyxa* in the sys-

* In several preparations which I had afterwards the opportunity of making, the corpuscles in question occurred in exactly the same way.

† A breaking-up into a greater number of small pieces also seems to me probable.

tem, I must admit that I am not in a position to range it with any previously known form. In the formation of the pseudopodia it has perhaps the greatest resemblance to *Orbulinella*. As regards the peculiar envelope consisting of fine bacilli, I can indicate no analogue of this. The only thing that has struck me is its resemblance to the coating of fine processes which Archer* has described in his *Diaphoropodon mobile*; but in the latter form the little rays are pseudopodia, and not rigid bacilli.

The completely closed envelope, traversed by pores, indicates a distant resemblance to the Perforata among the Foraminifera; while its want of consistence and the form of the pseudopodia, as well as the whole structure of the protoplasmic body, rather refer *Pachymyxa* to the amœbiform Rhizopods.

Together with the form that I have just described, there was also in the marine aquarium at the same place a number of naked masses of protoplasm, varying in size between about the dimensions which I have given above for *Pachymyxa*. These creatures, with regard to which I will hereafter endeavour to decide whether they are identical with *Pachymyxa* or not, show many interesting pecularities; so that I must give a detailed description of them.

In these also the protoplasm is characterized by its tenacity and density, so that none but extremely slow, scarcely visible, phenomena of motion are exhibited by it. These Rhizopoda are consequently also very opaque, especially if, as is frequently the case, they are filled with large brown food-masses. Very frequently such nutritive constituents are enclosed in the interior of a special large vacuole or digestive cavity, sharply marked off from the surrounding parts. At other times the balls lie scattered through the inner parenchyma of the body.

In general the external appearance of the individual specimens may be exceedingly different, as the protoplasm may at one time acquire an entirely granular texture, and at another a vesicular consistency full of vacuoles, and lastly appear hyaline and transparent. Very frequently a division into an external clear layer of protoplasm and an endoplasm filled with nutritive constituents may occur, the latter then representing a sort of nutritive paste. Such specimens (fig. 4) show a very regularly vacuolar exoplasm, from which the pseudopodia issue. The outer layer here exactly resembles that of an *Actinophrys sol*. Within it the endoplasm, coloured brown by the nutritive paste, is seen sharply differentiated.

* Quart. Journ. Micr. Soc. new ser. ix.; see also Bütschli, in Bronn's Kl. und Ordn. des Thierr. Taf. iv. fig. 1.

On one side of the individual figured (fig. 4) a second smaller one is seen to be attached; it is in process of fusion with the larger one, just as we shall observe hereafter in *Actinophrys*. Here only the endoplasm, *i. e.* the nutritive paste, was, in the first place, absorbed by the larger Rhizopod. The whole of the brown contents of the smaller individual flowed in a slow but constant stream into the larger one, so that finally there remained of the former only a clear mass of protoplasm, rich in vacuoles, but destitute of any nutritive particles, and from which also the pseudopodia had disappeared.

So long as I could observe the two specimens no complete fusion had taken place; but remarkable changes occurred in the larger Rhizopod. It entirely lost its regular form. The brown contents became balled together in several masses; the outer layer dissolved, so that in some places there remained only a fine zone which was pushed outwards by large vacuoles; in short, the form of the whole creature became exceedingly irregular, as if it were about to break up. Soon afterwards, however, it gradually approached the original form, which it finally almost completely resumed.

From this we see how little constancy there is in the separation into two regions in the Rhizopoda, and how easily plasmas temporarily appearing separated may become mixed together. The changes which have taken place in one and the same individual also furnish an indication why the forms here under consideration may be so different in respect of the structure of their protoplasm.

The behaviour of the pseudopodia is very remarkable. They do not issue as simple processes from the outer layer of protoplasm, but come forth as fine rods of uniform thickness from a cone of hyaline sarcode, exactly in the same way that I have recently described in the case of *Amœba tentaculata**. Here also the filament issues exactly from the apex of the cone; and when it is again retracted, there always remains a small cup-shaped depression. The pseudopodial cones, however, are usually much more numerous than in *Amœba tentaculata*, and also generally arranged with remarkable regularity (fig. 4).

In the above-mentioned *Amœba* the whole body, including the pseudopodial cones, appeared, under a high power, to be surrounded by a distinct double contour, which is not the case here, or, at least, could not be observed in by far the greater number of cases. Nevertheless here also, as in *Pachymyxa*,

* "Beiträge zur Kenntniss der Amöben," Zeitschr. für wiss. Zool. Bd. xxxvi.

which is furnished with an envelope, there exists an extremely fine layer of protoplasm as a coating over the whole body. I have previously asserted* that in all Rhizopoda the outer limit of the protoplasm acquires a different consistency by contact with the water, and that the flow of an *Amœba* or of a pseudopodium consists in a continuous breaking through this external membraniform layer on the part of the fluid sarcode yielding to a pressure, during which this layer is constantly being formed anew.

In most Rhizopoda this is not to be seen; and even in the present case we perceive nothing of it in the living animal. But this sort of cuticle is shown only the more distinctly by the application of reagents. Thus, if we kill the Rhizopods with osmic acid, stain them with carmine, and mount them in Canada balsam, the protoplasm contracts, and we see a fine membrane separated from it and reproducing its contour. If the preparation is successful, the pseudopodial cones with the pseudopodia themselves are preserved. In the fine membrane we then see very distinctly elevations at many points, each corresponding to a subjacent cone—a proof that the membrane, as a delicate layer, has enveloped the cones also, and been perforated by the pseudopodia. Here also I could never detect a nucleus; but with proper preparation and staining there appeared the same numerous red granules in the interior as in *Pachymyxa*. As in this, also, reproduction by division appears to be frequent.

The next question is where, from the characters described, we have to seek the allies of this Rhizopod. The most obvious course, perhaps, is to regard it as identical with *Amœba tentaculata*, which I also discovered at the same spot in our marine aquarium. Size cannot come into consideration in the comparison, as it is very variable in the different specimens; on the other hand, the phenomena of movement in *Amœba tentaculata* were quite different. The stage in which it emitted the pseudopodia described only represented a resting state, whereas otherwise it could pass into a constant flow, just like other *Amœbæ*, especially *Amœba quadrilineata*; moreover it possessed a distinctly visible typically formed cell-nucleus, both things which never came under observation here. It might indeed be assumed that this Rhizopod is a developmental stage of that *Amœba*, but this is very improbable.

But as regards the connexion of the form under consideration with the above-described *Pachymyxa*, the supposition seems almost inevitable that it is identical with the latter;

* *Loc. cit. suprà.*

for, leaving out of consideration the absence of a clothing with the small bacilli, the two forms have a number of agreements—such as the tenacious consistence and slight mobility of the protoplasm, the occurrence of numerous nucleiform corpuscles in the interior, the enclosure in a fine firm layer of protoplasm which, by a certain mode of preparation, stands forth like a cuticle, the form of the pseudopodia, and finally the mode of division. The only differences therefore are, that in one form pseudopodial cones are always formed, and that in the other the little bacilli of the skeleton are seated upon the peripheral layer of sarcode. I would therefore regard the last-mentioned Rhizopod only as another state of *Pachymyxa*.

2. *Amœba obtecta.*

Besides the *Pachymyxa* just described, I also found, in the small marine aquarium of the Zoological Institute here, another form of Rhizopod, and indeed an *Amœba*, which differs in many respects from the other species of its genus; and I have named it *Amœba obtecta*. It is very small, measuring only 0·03–0·04 millim., and does not creep freely about, but constructs a dwelling in which it conceals itself. As regards the latter, it is formed of a mucous substance of yellowish colour, which seems to harden more and more in water. The innermost part of the envelope which lies nearest to the *Amœba* is the firmest and the darkest-coloured; it forms the true carapace, while around it may lie an irregular zone of the yellowish substance, to which numerous granules and other foreign bodies firmly adhere.

In composition and coloration the substance of the envelope exactly resembles that which I have described in *Stichotricha socialis**. As regards its form, the carapace is basin-shaped (fig. 5); *i. e.* it possesses a rounded bottom and a wide aperture for the issue of the protoplasm. Frequently one half of the side wall has not been developed; and then the *Amœba* lies rather loosely in a simple saucer. The protoplasmic body which shelters itself in this envelope shows nothing remarkable that would distinguish it from the allied species of *Amœba*. The sarcode is tolerably tenacious and immobile, although far less so than in *Pachymyxa*. The portion that lies in the bottom of the basin is finely granular and turbid, while the opposite end, situated at the aperture, is clear, and appears formed of a hyaline mass. The pseudopodia originate from this; but I have only rarely been able to observe them, as the *Amœbæ* do not readily recover from the disturbances which

* "Neue Infusorien," Zeitschr. für wiss. Zool. Bd. xxxiii.

they undergo by their transfer to the object-slide. Generally we see only slow alterations in the hyaline mass; but once I succeeded in observing true pseudopodia (fig. 5). These were obtuse processes, one of which was forked at the end. Their movements were very slow. Such a specimen had thus some resemblance to a monothalamian Rhizopod. Nothing is to be seen in the living animal of a nucleus or a contractile vacuole. The latter is probably not present at all, as *Amœba obtecta* is a marine form; the nucleus, however, may be rendered very distinctly visible by means of reagents.

If the *Amœbæ* be treated in the fashion described at the beginning, and then stained with picrocarmine, the intensely reddened nucleus makes its appearance distinctly, even in a short time. It is seen sometimes at the posterior end of the body, sometimes in the middle, and it always appears as a uniformly red-coloured mass. The vacuoles in the protoplasm are also very well preserved under this mode of treatment.

As to the mode of reproduction of this *Amœba* I possess no observations. It certainly takes place by binary division; and the portion issuing from the shell will probably at once form a new envelope for itself. This seems to be shown by the circumstance that we very often find pairs of *Amœbæ* which lie with their carapaces quite close together.

These Rhizopods have evidently no tendency to undertake migrations, and hence, when the conditions are favourable, lie together in great quantities, and thus form regular societies.

[To be continued.]

XXXVII.—*On the Oœcium of* Spiralaria florea, *Busk*. By J. J. Quelch, B.Sc. (Lond.), Assistant, Zoological Department, British Museum.

The genus *Spiralaria* was established by Prof. Busk for the reception of the beautiful and curious Australian Polyzoon which he described and figured under the name *Spiralaria florea* in the 'Quarterly Journal of Microscopic Science,' new series, vol. i. (1861) p. 153. The same species has since been redescribed and figured by Prof. M'Coy in the 'Prodromus of the Zoology of Victoria,' decade v. (1880) p. 31; and supplementary information is given as to the nature of the mouth of the cell, of the avicularia, of the margin of the cell, and of the lamina on which the cells are placed; but no mention is made by this latter observer of the occurrence of oœcia. These were absent from the specimen which was described by Prof. Busk; and as I can find no record of them