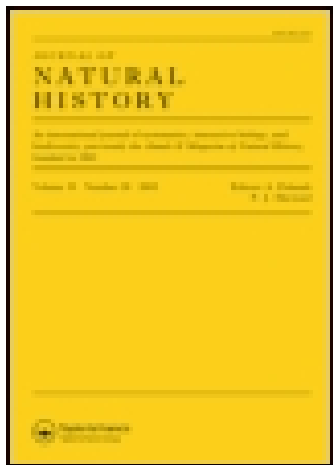


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### XIV.—On the fundamental error of constituting *Gromia* the type of foraminiferal structure

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shell-dealer, of which I possess specimens. This species was dredged by the late Professor Barrett at Jamaica; and it is a fossil of the Sicilian Tertiaries. I received specimens of the latter from the Marquis di Monterosato as "*Cadulus subfusiformis*, Sars," and from Dr. Tiberi as "*Siphonodentalium Olivi*, var. *minor*, Scac."

An undescribed species of *Cadulus*, dredged by Admiral Sir Edward Belcher in the N.W. Pacific (for specimens of which I am indebted to his kindness), is also allied to *C. Olivi*; but the narrower and smaller extremity has four slight notches and corresponding slits. It is therefore possible that the genera *Siphonodentalium* and *Cadulus* should be united, and that *Dischides* must "follow suit."

*Cadulus cylindratulus*\*, Jeffr.

SHELL forming a narrow cylinder, slightly contracted at each end, gently curved, thin, transparent, and glossy: *sculpture* none, except a few microscopic and faint lines of growth: *mouth* somewhat obliquely truncated, but not thickened: *base* circular, with numerous minute notches, which are not perceptible to the naked eye. L. 0.325. B. 0.075.

Station 12, 1450 fms.; a single specimen. 'Porcupine' Expedition, 1869, off the West of Ireland, 1215-1476 fms.; very rare.

XIV.—*On the Fundamental Error of constituting Gromia the Type of Foraminiferal Structure.* By G. C. WALLICH, M.D., Surgeon-Major Retired List H.M. Indian Army.

RATHER more than forty years have elapsed since the first attempt was made by Dujardin to classify the Rhizopods. During the latter half of this period, the study of these singular organisms has not only been invested with much additional scientific interest, but has received a powerful impetus from its intimate connexion with the geological and biological relations of the deep-sea bed. And yet our knowledge of the Rhizopods as a whole, and especially of the animal portion of their structure, is by no means so complete as it ought to have been, considering the amount of attention that has been bestowed upon it. This, I venture to think, is in a great

\* Cylindrical.

measure attributable to the fundamental error which pervades that classification of these organisms which has hitherto been very generally, and in other respects very deservedly, held in high estimation by naturalists.

In an article upon the Systematic Arrangement of the Rhizopoda, by Dr. W. B. Carpenter, published in the 'Natural-History Review' for October 1861, the author thus expresses his views on the subject:—"It is, as it seems to me, in the *structural and physiological conditions of the animal alone* that we should look for the characters on which our primary subdivisions should be constituted; and notwithstanding that the extreme simplicity and apparent vagueness of those conditions appear almost to forbid the attempt to assign to them a differential value, yet a sufficiently careful scrutiny will make it clear that, under their guidance, lines of demarcation may be drawn as precise as in any other great natural group, between three aggregations of forms which assemble themselves round three well-known types, *Amæba*, *Actinophrys*, and *Gromia*,—the sarcode-bodies of these three types presenting three distinct stages in the differentiation of the protoplasmic substance of which they are composed, and exhibiting, in virtue of that differentiation, three very distinct modes of vital activity" (*loc. cit.* p. 460).

Regarding the perfect soundness of the principle laid down in the opening sentence of the above extract, it may at once be assumed that no question can arise. But this renders it only the more inexplicable that such a thoroughly illogical application of the principle should have followed as is involved in the separation from each other, and the location in three distinct ordinal divisions, of *Amæba*, *Actinophrys*, and *Gromia*—three forms in each of which are prominently combined the only true *structural* characters of the animal that clearly indicate an advance, in the highest group of Rhizopods, towards the more complex organization of the Infusoria and Gregarinæ.

The structural characters here referred to by me consist in the possession, in common, by *Amæba*, *Actinophrys*, and *Gromia*, of a NUCLEUS and CONTRACTILE VESICLE:—the former being the reproductive organ of the Rhizopod in its most fully developed condition; the latter, a fluid-respiratory organ, to be met with, so far as my experience goes, for the first time in the third or highest order of the Rhizopods\*. On these grounds I have done my utmost, for the last twelve years, to prove that the three genera referred to cannot be thus parted

\* See Supplementary Note at the end of these observations.

without doing violence to the most natural and important of all affinities, namely those founded on the "structural and physiological conditions of the animal alone."

But, irrespectively of this, were further proof needed of the error committed in the separation of these three genera on the basis of differences supposed to be more or less constantly observable in the characters of their respective *pseudopodia*, and the accompanying degrees of "differentiation" said to exist respectively in the external layer of the body, or "ectosarc," and the general protoplasmic mass within, or "endosarc," I undertake to show, on Dr. Carpenter's own evidence, that the pseudopodial characters are by no means sufficiently uniform or sufficiently constant to be depended upon as ordinal distinctions. In short, I hope to make it clear that the terms "ectosarc" and "endosarc" embody a scientific fiction, and that the sole purpose they serve is to mask our ignorance. The sooner, therefore, they are dispensed with, save as convenient names for the portions of the sarcode-mass that happen for the time being to constitute the external boundary and the internal mass, the sooner may we expect to arrive at an adequate idea of the visible characters which distinguish the organism called a Rhizopod\*.

Dr. Carpenter, in defining the characters of the lowest order in his system, namely the *Reticularia*, tells us that "in the cases in which the differentiation into ectosarc and endosarc has proceeded furthest, so that that body of the Rhizopod bears the strongest resemblance to an ordinary 'cell' † (as is the case with *Amœba* and its allies), a *nucleus* may be distinctly traced; in those, on the other hand, in which the original protoplasmic condition is most completely retained (as seems to be the case with *Gromia* and the Foraminifera generally), no *nucleus* can be distinguished. The same," he says, "appears to be true of the peculiar *contractile vesicle*, which may be regarded as a vacuole with a defined wall" ('Introduction to the Study of the Foraminifera,' 1862, p. 14).

Dr. Carpenter afterwards goes on to make the following

\* For a detailed account of my observations on the Rhizopods generally, I would refer the reader to a series of six papers on the *Amœban*, *Actinophryan*, and *Diffugian* Rhizopods, contributed by me to the 'Annals' between April 1863 and March 1864; and a paper "On the *Polycystina*," embodying a Classification of the Rhizopods as a whole, and this family in particular, which was published in the 'Quart. Journ. Micr. Soc.' for July 1865.

† Biology and physiology are undoubtedly under heavy obligations to the "cell" doctrine. But it is not saying too much to assert that biologists and physiologists have had a great deal of nasty work cut out for them by the perpetual misapplication and misconception of that doctrine.

very specific statement:—"The subdivision of the Rhizopods into orders seems to be most satisfactorily accomplished by taking as a basis those structural characters which are most expressive of physiological differences. Such characters are presented in the form, proportions, and general arrangement of the pseudopodial extensions; for, notwithstanding their apparently unrestricted *polymorphism*, it will be found that the Rhizopods present three *very distinct types of pseudopodian conformation*, to one or other of which they may all be referred, *and that the groups thus formed are eminently natural*. How intimately related these diversities are to those *fundamental potentialities* of each type which find so little structural expression in the lowest form of animal life, appears from the circumstance that *even a particle of protoplasm, detached from the general mass of the body, will put forth the pseudopodian extensions characteristic of its type*,—those of the substance forced out by crushing the 'test' of an *Arcella* having the broad, lobated form of those of the *Amœba*, whilst those of the substance forced out in like manner by crushing the shell of a *Polystomella* have the delicate thread-like character of those of the Foraminifera generally" (*op. cit.* pp. 14 & 15).

Here, then, we have a clear and definite admission on Dr. Carpenter's part that the presence of a *nucleus* and of a *contractile vesicle* is indicative of the highest stage of structural organization of which the Rhizopods are capable. And I take it for granted, therefore, that, conversely, it is meant to be inferred that the absence of both of these organs indicates the lowest stage, the zero, of organization. Yet, extraordinary as it must appear, it is not upon the presence or the absence of one or other or both of these important specialized organs that Dr. Carpenter has based his classification, but "on the characters presented by the form, proportions, and general arrangement of the pseudopodial extensions"—characters which, even if constant and uniform, could not possibly compare with them in point of physiological significance, but which, if shown to be both so inconstant and fluctuating as to present themselves with nearly equal frequency in the highest and in the lowest orders into which the Rhizopods are divisible, and even to vary entirely in the same genera, cannot be regarded as otherwise than illusory, and therefore worthless for the purpose of ordinal subdivision.

I do not mean to assert that the evidence of advance from the lower to the higher grade of organization on which I have invariably laid the greatest stress, namely the appearance of a *nucleus* and a *contractile vesicle*, may not be accompanied by perceptible differences in the general aspect of the sarcode

(nor has this ever been my opinion), but only that these differences are neither commensurate in importance, nor at all sufficient in kind, or sufficiently constant, to be admissible as proofs of such advance. And this will be seen from the following short extract from my observations on the Polycystina, taken from the 'Quarterly Journal of Microscopical Science' for July 1865:—"Although not prepared to regard the degrees of differentiation (as described by Dr. Carpenter) as applicable to the demarcation of orders, or as affording perfectly constant characters *under any circumstances*, there cannot be a doubt as to their affording, in the majority of cases, a valuable means of completing *generic* diagnosis. Beyond this their value does not appear to extend."

The only point which might reasonably be deemed open to discussion (though probably not by any one who has witnessed the behaviour of the body-substance of *Actinophrys sol* when being torn to bits and devoured piecemeal by an *Amœba*) is that alluded to when Dr. Carpenter says that "a particle of protoplasm detached from the general mass of the body of a Rhizopod will put forth the pseudopodia characteristic of its type,"—*Arcella* being specified as putting forth the "lobose" pseudopodia of *Amœba*, and *Polystomella* (itself a Foraminifer!) being, curiously enough, singled out as putting forth the "delicate thread-like" pseudopodia of—the Foraminifera\*.

As interpreted by me, the appearances here described, although not indicative of sufficiently important or constant "differences" in the constitution of the exterior layer and interior protoplasmic mass to be available as ordinal distinctions, prove in a very decisive manner that there *cannot* be any thing approaching to a definite external layer†; unless we are also prepared to believe, because an oil-globule retains its form whilst suspended in pure water, or, if split up

\* Those who have studied the living Foraminifera, and know to their cost how much time and patience is necessary in getting these intensely sensitive beings to project their pseudopodia at all, will, I think, agree with me that there is more conveyed in Dr. Carpenter's statement on this point than could possibly have been intended by him. For two whole years the naturalists on board the 'Challenger' watched constantly and anxiously before their eyes were rewarded with a sight of the projected pseudopodia of the ubiquitous Foraminifera of the open ocean. He must have been an exceptionally fortunate observer, therefore, who saw the crushed "particle" of the complex-shelled *Polystomella* put forth the pseudopodia of its tribe.

† Of course I except what is observable when the final stage of the life-cycle of *Amœba* has arrived, namely its encystment, as having no real bearing on the present question.

into two portions, each of these behaves precisely as another oil-globule does by instantaneously presenting an unbroken outline, that the said oil-globule is differently constituted at its surface and in its interior. The same argument applies, and with redoubled force, to a mass of albumen suspended in water; for here the tendency to assume a spherical form is by no means so pronounced as in an oil-globule; and if we break up the mass into a number of smaller masses, we have presented to us appearances which very closely resemble those observable in the pseudopodium of the *Amæban* Rhizopod. Indeed so close is the resemblance, that, barring the element of vitality (which the chemist is still as far off as ever from producing at call), we have before our eyes those very "fundamental *potentialities*" which a highly imaginative rendering of certain appearances has declared to be typical of the living sarcode of the Rhizopod.

Were it not that it befits us to speak with bated breath of the mighty dead, another instructive argument on this subject might be adduced from the history of the rise and fall of the unfortunate "*Bathybius*."

But the fact is, that, divide the sarcode body of a living *Amæban*, or even an *Actinophryan*, Rhizopod as we may, by pressure or other agency, the *divided surface* will forthwith present every character presented by the undivided portion: any peculiarity of outline, if present in the undivided part, will at once reappear in the divided part; any seeming contrast between the external layer and the contained mass within will instantly show itself; and the character of the pseudopodial processes will be the same. This identity of character in the divided and undivided surfaces is absolutely instantaneous, there being nothing like a gradual transition from one condition to another, such as we should undoubtedly be able to see taking place were the ruptured surfaces in any respect dissimilar to the rest of the mass. This is the view I have always advocated, its unacceptable point being, I presume, that it is quite unconformable with Dr. Carpenter's published definitions of Rhizopod structure.

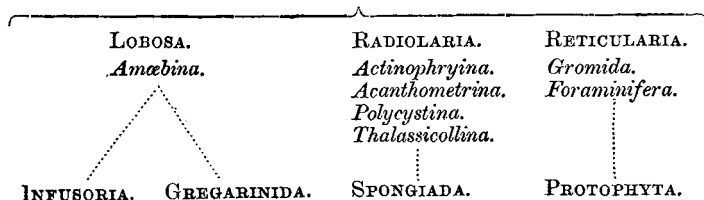
As it would be foreign to the immediate purpose of the present paper to enter into all the details of the subject, I must confine myself to stating that the inconstancy of the pseudopodial characters in *Amæba*, which is of course quite incompatible with the assumed presence of an external layer of much more highly developed sarcode than that which it encloses, is conceded (but without the inevitable inference which must be associated with it) in the 'Introduction to the Study of the Foraminifera,' 1862 (p. 23), when Dr. Carpenter says



that “sometimes *Amœba* puts forth a few broad lobated expansions; sometimes these are more numerous, slender, and elongated, *assuming a radial direction*; and occasionally they are so greatly multiplied, *radiate with such regularity, and taper so uniformly from base to apex, as strongly to resemble the pseudopodia of ACTINOPHRYS.*”

This is undoubtedly true; and I therefore leave Dr. Carpenter to reconcile the fact with his classification and definitions of the orders, of which I now subjoin a summary, taken from his paper in the ‘Natural-History Review’ to which reference has already been made\*.

*Dr. Carpenter’s Arrangement of the RHIZOPODA.*



After saying that “any small separated portion of the sarcode body of the Rhizopoda will behave itself after the characteristic fashion of its type” (that of *Arcella* behaving like that of *Amœba*, that of *Polystomella*, or any other of the Foraminifera, like those of *Gromia*), and adding that “this fact seems to him to afford an additional justification of the employment of the characters furnished by the *pseudopodia* as the *basis* of a systematic arrangement of the class,” he informs us that the characters of the three orders into which he proposes to distribute its various forms may be concisely summed up as follows:—

“I. RETICULARIA.—The body composed of homogeneous granular protoplasm, without *any* distinction into ectosarc and endosarc; neither nucleus nor contractile vesicle; pseudopodia composed of the same substance as the body, extending and multiplying themselves by minute ramification, and inosculating completely wherever they come into contact; a con-

\* It may be well to bear in mind that the article in the ‘Review’ appeared in 1861 as an *avant-courier* to the ‘Introduction to the Study of the Foraminifera,’ which appeared just a year afterwards. The tabular classification of the Rhizopods is taken from page 17 of the latter work.

tinual circulation of granular particles throughout the viscid substance of the body and its extensions. This order consists of the Foraminifera and the *Gromida*.

"II. **RADIOLARIA**.—Incipient differentiation of the protoplasmic substance into endosarc and ectosarc, the former semi-fluid and granular, the latter more tenacious and pellucid; a nucleus and contractile vesicle; pseudopodia rod-like, tapering from base to point, composed of the same substance as the ectosarc, exhibiting little disposition either to ramify or coalesce, although a movement of particles adherent to their exterior is often to be distinguished. The type of this order is *Actinophrys*.

"III. **LOBOSA**.—More complete differentiation of the protoplasmic substance into endosarc and ectosarc, the former being a slightly viscous granular liquid, and the latter approaching the tenacity of a membrane; a nucleus and contractile vesicle; pseudopodia few and large, being in reality lobose extensions of the body which neither ramify nor coalesce, having well-defined margins, and not exhibiting any movement of granules on their surface, the circulation in their interior being entirely dependent on the changes of form which the body undergoes as a whole."

As regards those "*fundamental potentialities of each type*"—which, according to Dr. Carpenter, find a much more accurate physiological expression in the "form, proportions, and general arrangement of the pseudopodial extensions" than in the definite *step-by-step* advance from the simplest condition of the body-substance, observable in the Foraminifera (in which there is only the faintest foreshadowing of any thing akin to reproductive organization\*), to the intermediate stage, in which this foreshadowing shows itself in the shape of a centralized but still imperfectly aggregated mass, and, finally, to the highest stage, in which the reproductive gemmules assume the concrete form of a distinct specialized nucleus (the culminating point being marked, at the same time, by the association of the nucleus with a specialized respiratory organ,

\* It was shown by me that the "*yellow cellules*" of MM. Claparède and Lachmann, or more or less colourless homologues of these "*cellules*," occur in the sarcode of all the Rhizopods without exception, that in the lowest order they are formed, as it were, from minute granules uniformly distributed in the sarcode, that in the second and third orders they are formed by the splitting-up of the nucleus (which is in these a specialized reproductive organ), but that in all three orders they constitute the *sarcoblast*, or, in other words, the earliest visible embodiment of the young organism. See Ann. & Mag. Nat. Hist., June 1863 (where these bodies are figured), Dec. 1863, March 1864; and Quart. Journ. Micr. Science, July 1865.

namely the *contractile vesicle*)—I venture to say that however plausible Dr. Carpenter's hypothesis may be, it finds no response in nature. And I maintain that we are furnished with the most complete proof that could be desired of the invalidity of the characters derived from the pseudopodia for purposes of ordinal classification, in the passage from Dr. Carpenter's own writings quoted at p. 164. At all events I confess that it is quite beyond my humble powers to reconcile the admissions there made on Dr. Carpenter's part with his allegation, already quoted, that "the sarcode bodies of his three types *Amæba*, *Actinophrys*, and *Gromia* present three distinct stages in the differentiation of the protoplasmic substance of which they are composed," and that "the lines of demarcation thus drawn are as precise as in any other great natural group, between the three aggregations of forms which assemble themselves round the three well-known types" above named.

But in order to prevent all misconception on this very important question, I must request attention to another extract from Dr. Carpenter's observations on the Systematic Arrangement of the Rhizopods (Nat. Hist. Rev. 1861, p. 461), where he states that "the ordinal designation *Reticularia* is meant to express the reticulous arrangement of the pseudopodial extensions, *which is its distinguishing character*." And again, at page 463, he says that "the radiating pseudopodia of *Acanthometra* correspond *precisely in all their characters* with those of *Actinophrys*, having the same rod-like tapering form, and same regular radiating arrangement, the same mutual isolation, the same slow movement of particles along their surface; some of them are, however, enclosed in *tubular* sheaths\*, the differentiation of *Acanthometra* into ectosarc and endosarc having obviously proceeded further than in *Actinophrys*."

But although it is true that in *Acanthometra* the differentiation into ectosarc and endosarc *has* proceeded further than in *Actinophrys*, it is equally true that it has also proceeded further than in *Amæba*. But even stopping short at Dr. Carpenter's point, that it has proceeded *further* than in *Actinophrys*, how can this be reconciled with the statement that "the radiating pseudopodia of *Acanthometra* correspond

\* It was pointed out by me years ago that the appearance of *tubularity* in *Acanthometra* is altogether an illusion. There is no such thing as a tubular portion in the structure of these organisms. See a paper "On the Process of Mineral Deposit in the Rhizopods and Sponges," Ann. & Mag. Nat. Hist., Jan. 1864.

*precisely* in all their characters with those of *Actinophrys*”? The fact is that the pseudopodia of no other Rhizopods could possibly present appearances more distinct from each other, both as regards habit and arrangement, than those of these two organisms.

From what has already been brought forward it will be seen, I think, that the question under discussion, namely the error of making *Gromia* the type of foraminiferal structure, is reduced within very narrow limits. In short, it resolves itself into this:—Is the practically imperceptible degree of organization, which Dr. Carpenter ascribes to the lowest or Reticularian order in his system, exemplified, as he pronounces it to be, in the type *Gromia*? Of course, if it be not so exemplified, and if it can be shown, on the one hand, that the so-termed typical pseudopodia of *Gromia* may be identical in all respects with the pseudopodia of the Foraminifera which Dr. Carpenter associates with *Gromia*, and, on the other hand, that *Gromia*, the reputed type of extreme primordial simplicity, besides having pseudopodia identical with certain Actinophryans, possesses both the *nucleus* and a *contractile vesicle* (which Dr. Carpenter allows to be distinctive of the highest degree of physiological development in the Rhizopod), there is, of course, on Dr. Carpenter's own showing, an end to his arrangement of these organisms on the basis upon which it has heretofore rested; and, what is more, there must be an end to every other classification of the Rhizopods which is based, in like manner with his, on characters derived primarily from the pseudopodia. There is no alternative, so far as I can see. And yet, as will presently appear, knowing these facts, Dr. Carpenter is quite unable to brace himself up sufficiently to make the necessary recantation candidly and ungrudgingly.

In my remarks “On the Distinctive Characters of *Amœba*” (‘Annals,’ Aug. 1863) it was mentioned that I had discovered a well-marked *nucleus* in *Gromia*, but had not, at that time, detected a contractile vesicle. In view, however, of the analogies existing between *Gromia* and the *Amœba*, so confident was I that the organ was there, that I expressed my conviction that I should speedily be able to trace the contractile vesicle also, adding that, if traced, the transfer of *Gromia* from the lowest to the highest order would of course be inevitable. Having for many months, both before and afterwards, spent many hours daily in watching the changes taking place in specimens of various genera of Rhizopods kept in tanks, I was fortunate enough in November of the same year to see the long-looked-for contractile vesicle in *Gromia*. This

was announced in my "Further Observations on the Distinctive Characters and Reproductive Phenomena of the Amoeban Rhizopods," published in the 'Annals' of Dec. 1863. And at a still later period, when I had managed to establish several colonies of healthy *Gromia* in my tanks, I had ample opportunities of verifying my earlier observations in a sufficient number of cases to render all further doubts on the subject inadmissible. I may add that my examinations embraced both freshwater and marine forms of *Gromia*, and that no material distinction presented itself between the characters of the two sets of specimens, beyond differences in size and colour, or, I should rather say, in the presence or absence of dirt on the otherwise nearly hyaline tests—the dirt being generally present on the freshwater form, and as generally absent on the saltwater one. After a time there was not the slightest difficulty experienced in finding plenty of sufficiently clean and hyaline tests to admit of the easy detection of the two organs under notice.

In the latest (1875) edition of 'The Microscope and its Revelations,' Dr. Carpenter takes a first cautious step towards a change of front, without, however, pointing out (as he might with a very good grace have done) that his entire classification was sapped to its foundations by the discovery that *Gromia*, whose *pseudopodia* he had declared to be precisely similar to those of the lowest and simplest known form of Rhizopod, possesses the two specialized organs which only make their appearance "in the cases in which the differentiation into ectosarc and endosarc has proceeded furthest." This omission will perhaps explain itself on the publication, side by side, of the two subjoined short extracts:—

1862. "Notwithstanding the apparently unrestricted polymorphism of the pseudopodial extensions, it will be found that the Rhizopods present three *very distinct types of pseudopodial conformation*, to one or other of which they may all be referred, and that all the groups are *eminently natural*." (Introd. Study Foram. p. 15.)

1875. "To the first of the orders thus marked out, the name *Reticularia* seems appropriate; the second has been distinguished as *Radiolaria*; and the third may be designated *Lobosa*. It must be freely admitted, however, that these groups cannot be distinctly marked out, the *typical* examples which will now be described being connected by *many intermediate forms*. This is not to be wondered at, when the extreme indefiniteness which characterizes the lowest type of animal life is duly borne in mind." (The 'Microscope and its Revelations,' 5th edit. p. 467.)

Again, at p. 470 of Dr. Carpenter's work 'The Microscope,' referring to the *Reticularia*, he continues:—"There is, moreover, a negative character of much importance which is naturally associated with the absence of differentiation, namely the deficiency of the 'nucleus' and of the 'contractile vesicle,' that present themselves alike in the *Radiolaria* and the *Lobosa*. It is by animals belonging to this order that those very remarkable minute shells are formed which are known as *Foraminifera*. In *Gromia*, however, we have an example of a Rhizopod which *very characteristically* exhibits the Reticularian type in the disposition of its pseudopodia, but which Dr. Wallich was the first to point out possesses both a nucleus and contractile vesicle, thus showing a *transition* to the higher orders"! That is to say (at least if there is any meaning in words) that the presence of the very organs in *Gromia*, the absence of which he had in the same page declared to be "a negative character of much importance, naturally associated with the absence of differentiation" merely shows that it is a transitional form between the *very lowest* and the *very highest* of the whole series of Rhizopods!

But Dr. Carpenter's extreme reluctance to relinquish his published opinions even when they are demonstrated to be untenable is only on a par with the vehemence with which he is in the habit of enforcing his evidence when he has a theory to support. Referring to M. d'Orbigny (Intr. Study Foram. p. 63), he says:—"By M. d'Orbigny the family *Gromida* was altogether ignored, no member of it having been known when he first applied himself to the study of the Foraminifera, and no mention having been made in his subsequent writings, even of the typical genus *Gromia* described by M. Dujardin in 1835, notwithstanding the clear demonstration given by that admirable observer of its close relationship to *Miliola*."... "Between the 'test' of *Gromia* and that of *Arcella*, indeed, there is little difference; but *between the animals which form and inhabit these 'tests' respectively, the difference is as wide as any known to exist in the whole Rhizopod series*"!

Lastly, as it is with the *Reticularia* of Dr. Carpenter, so must it be with the *Radiolaria*. Both of these ordinal designations presuppose the existence of characters on which not the slightest reliance can be placed; whilst they serve effectually to mask, if not entirely to supersede, those truly important characters by means of which the gradational advance from the most simple to the most complex type of Rhizopod structure can at a glance be recognized. Indeed, either ordinal name may with equal aptitude be applied to the

families which are ranked in the other orders. Thus the name *Radiolarian* is just as appropriately applied to the pseudopodia of some of the "perforate" Foraminifera as to those of the *Polycystina*, which are placed by Dr. Carpenter in his second order, the *Radiolaria*, under the erroneous idea that they and the other families which he associates with them in that order possess both a nucleus and a contractile vesicle. *Actinophrys*, which he makes the type of this order, undoubtedly possesses both organs; but it is the only form in the *Radiolarian* order (as constituted by Dr. Carpenter) which is so gifted. It is consequently quite out of place elsewhere than in the third or highest order, in which every family, without exception, possesses both these organs. The *Polycystina*, on the other hand, do not possess a definite nucleus, their body-substance being almost identical in its degree of "differentiation" with the body-substance, for example, of *Orbulina*. It is quite unnecessary for me to point out that since the nature of the animal of the *Foraminifera* and of the *Polycystina* is to all intents and purposes identical, no valid objection to their association in the lowest of the orders into which the Rhizopods are divisible can with justice be based on the mere difference in the mineral constitution of their shells.

It is well to bear in recollection that Müller based his classification of the Rhizopods on the purely artificial difference between the naked and the shell-covered forms. His designation of "*Radiolarie*" is certainly not retained therefore out of deference to the meaning which its propounder attached to it. But inasmuch as an attempt is being made to supersede the name of *Polycystina* given by Ehrenberg to these organisms by calling them *Radiolaria*, and, according to every rule of priority\* and scientific usage, "*the name originally given by the founder of a group should be permanently retained to the exclusion of all other synonyms*," unless some good cause can be assigned for the change, I must say the procedure appears to be altogether unjustifiable. For if it be urged that the meaning lurking under the name *Polycystina* is misleading, what is to be said of the name of *Foraminifera* as applied to a *Miliola* or a *Lagena*?

The following is the classification of the Rhizopods which was appended to my paper on the *Polycystina* in 1865. I beg leave to submit it once more to naturalists without comment or modification of any kind, either in the tabular por-

\* See "Rules for Zoological Nomenclature," authorized by Section D of the British Association, 1842. Reprinted by requisition of Section D at Newcastle, 1863, p. 9.

# RHIZOPODA.

No definite nucleus. No contractile vesicle.		Definite nucleus. No contractile vesicle.		Definite nucleus. Contractile vesicle.	
1.		2.		3.	
HERPNEMATA *.		PROTODERMATA †.		PROTEINA ‡.	
Shell never siliceous.	Skeleton invari- ably siliceous.	Skeleton solid.	Skeleton tubular.	Pseudopodia monomorphous.	Pseudopodia polymorphous.
	POLYCYSTINA.	DICTYOCIDÆ.			
FORAMINIFERA.		PLAGIACANTHIDÆ.		ACTINOPHERYNA.	
Ileberkulnia? (Clap.).		ACANTHOMETRINA.		Actinophrys.	
Pamphagus? (Bailey).		THALASSICOLLINA.		Gromia.	
				Lagymis.	
				Euglypha.	
				Cadium (Bail.).	
				Protocystis (Wal.).	
				Platophrys? (Clap.).	
		SPONGIDÆ.		Pseudochlamys.	
				AMEBINA.	
				Amæba.	
				Diffugia.	
				Arcella.	
				INFUSORIA.	

\* From ἑρπω, to creep and νῆμα, a thread.

† From πρῶτος, first or earliest, and δερμα, skin.

‡ This name is adopted from the classification of MM. Claparède and Lachmann, inasmuch as the order so designated comprises the two families whose affinities they recognized, although on grounds which appear to me of very minor importance as compared with those now adduced.



tion or the general definitions. Owing to an oversight when the MS. was sent to press in 1865 the words "*monomorphous*" and "*polymorphous*" were omitted under the twice repeated word "*Pseudopodia*" in the third order *Proteina*. These have, therefore, been now inserted (see p. 171).

Order I. *HERPNEMATA*.—The Primary and Secondary characters of this order are as follows:—No definite nucleus. No contractile vesicle. Sarcod without any appreciable differentiation into endosarc and ectosarc, consisting of homogeneous viscid protoplasm, in the substance of which vacuolar cavities occasionally occur. Pseudopodia forming anastomoses, and exhibiting, both along the surface and within their substance, the phenomena of *pseudo-cyclosis*\*.

Order II. *PROTODERMATA*.—Definite nucleus present, but no contractile vesicle. Sarcod so far advanced in differentiation that the ectosarc constitutes a nearly hyaline stratum of greater tenacity than the endosarc, which still retains much of the general consistence of that of the *Herpne-mata*. The transition, however, from endosarc to ectosarc is gradual. Here, as in the last-named family, vacuolar cavities occur. The pseudopodia, *when present*, are scattered and attenuated, rarely coalescing, for the most part rigid, but still highly contractile, and exhibiting in their interior and on the surface only such minute granules as find their way into the ectosarc. Pseudo-cyclosis manifest. Sarcoblasts conspicuous†.

Order III. *PROTEINA*.—A definite nucleus and, with it, a contractile vesicle; sarcod very highly differentiated into endosarc and ectosarc: the former granular, more or less nearly colourless, very viscid, and exhibiting but little contractility; the latter nearly hyaline and very contractile, but never assuming a membranous consistence, except during the period of encystation. Vacuolar cavities numerous and constant, seen principally to occur in the endosarc. Sarcoblasts abundant and frequent, but, owing to their pale colour, less easily detected than those of the oceanic *Rhizopods*‡.

It only remains for me to add:—that the above classification

\* A term applied by me to indicate that there is no such thing in the *Rhizopods* as a circulatory movement of any kind, apart from the inherent contractile movement of the sarcod. If that ceases for a moment, the movements of the granules cease. See "Further observations on *Amœban Rhizopods*," *Ann. & Mag. Nat. Hist.* Nov. 1863.

† See page 165, *antè*, note. Sarcoblast was the name given by me to the "yellow cellules" of MM. Claparède and Lachmann, indicating their reproductive function, which these observers had failed to recognize.

‡ For the complete details of this classification I must refer the reader to the '*Quarterly Journal of Microscopical Science*' for July 1865, in which they were first published.

is by no means put forth as perfect in all its parts, but simply as embodying what I conceive to be, for reasons already assigned, as close an approximation to a natural arrangement of the Rhizopods as the present state of our knowledge allows; and that, having done my best during the course of the past twelve years to test it whenever opportunities occurred, I have not been able to detect any serious flaw in it. It must nevertheless be accepted merely as an attempt to reduce the group of organisms in question to something like natural order.

#### SUPPLEMENTARY NOTES.

*Contractile vesicle.*—It has always been urged by me that there is more reason for regarding the contractile vesicle of the Rhizopod as an organ whereby the effete residue of the watery fluid absorbed by the animal is first collected, and then discharged by an orifice in the vesicle, *extemporized* at the moment of extreme dilatation, than for regarding it as a circulatory organ. I may therefore be allowed to point out that although the nature of this organ was discussed by me in detail in the 'Annals' for December 1863, and it was there shown (both on the independent evidence of my friend Mr. Carter, and as the result of my own observations) that the contractile vesicle in *Amæba*, *Actinophrys*, and certain *Infusoria* discharges its contents at the immediate surface of the animal's body (my description of the process being accompanied by illustrative figures), Dr. Carpenter has not scrupled to say, at p. 472 of his work 'The Microscope' (5th Edit. 1875), that the nature of the process was for the first time "fully established by Dr. Zenker in 1867"—and this in the same page in which he shows that he was acquainted with my series of papers in the 'Annals' upon the Rhizopods, in which the observations were recorded.

*Noctiluca.*—In the Report of the 'Challenger' Expedition, published in the Proceedings of the Royal Society, 1876, vol. xxiv. pl. 21, there are three figures which are described as representing "*true Diatoms*," to which the generic name of *Pyrocystis* has been given by the discoverers. I am, indeed, grievously mistaken if these structures bear the slightest affinity to Diatoms, or are any thing else than true oceanic *Noctiluca*. It would be just as irrational to separate the testaceous from the naked Rhizopods, because the former have hard coverings and the latter have none, as to regard these new forms as distinct from *Noctiluca*, because they present a delicate siliceous wall. The figures of the elongate form, if accurate representations, as they doubtless are,

show at a glance that the structure is *not* that of any Diatom.

*Dictyocha*.—In Dr. Gwyn Jeffreys's Report on the 'Valorous' Expedition (Proc. Roy. Soc., June 1876, p. 228), there is an account of some Diatoms examined by Professor Dickie, it being mentioned incidentally that along with these "were two *Polycystina*, namely *Dictyocha fibula*, Ehr., and *Dictyocha gracilis*, Ehr." With all deference to Prof. Dickie, I beg leave to point out that the *Dictyochidæ* are neither Diatoms, as they have been regarded by some writers, nor *Polycystina* as they would now appear to be regarded by others. They are *Rhizopods*, holding an intermediate place between *Thalassicolla* on the one hand, and the siliceous sponges on the other; and hence (as was long ago shown by me) they constitute the true connecting link between the Rhizopods and the Sponges. The basket-shaped framework of the *living Dictyocha* is never single, but invariably double, the concavities being placed face to face, and the two portions retained in position solely by the sarcode body, which fills and surrounds them. The distinct *nucleus* may always be seen, in recent specimens, suspended as it were in the middle of the sarcode, half within the boundary line of one framework, half within that of the other. The most remarkable feature, however, of *Dictyocha*, and the one which at once establishes its alliance with the siliceous sponges, is that *every* part of the siliceous framework is *tubular*.

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#### BIBLIOGRAPHICAL NOTICES.

*The Primæval World of Switzerland.* With 560 Illustrations. By Professor HEER. Edited by JAMES HEYWOOD, F.R.S. &c. 2 vols. 8vo. Longmans & Co.: London, 1876.

*The Geology of England and Wales.* By HORACE B. WOODWARD, F.G.S. &c. With coloured Geological Map and numerous woodcuts. 8vo. Longmans & Co.: London, 1876.

ENGLAND and Wales have been said to exhibit an epitome of geology to the student of successive rock-formations and fossiliferous strata. From the oldest and lowest, or nearly lowest, known series of rock-masses, now much altered, to the latest or uppermost deposits of sea, lake, and river, some representative rock or layer is found in place, indicating period after period of the earth's history, as far as geologists can recognize its terraqueous existence.

Switzerland also presents an epitome of the geological history of