

NOTES on some of the RETICULARIAN RHIZOPODA of the
 "CHALLENGER" EXPEDITION. By HENRY B. BRADY,
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PART III.

1. *Classification.*
2. *Further Notes on New Species.*
3. *Note on Biloculina Mud.*

IN two previous papers ('Quart. Journ. Micr. Sci.,' Jan. and April, 1879) I have endeavoured to indicate some of the more important results that have been obtained by the examination of the material obtained by dredge and tow-net during the "Challenger" expedition, in respect of the large and varied group of testaceous Rhizopoda, which it is the custom to speak of under the general term Foraminifera or Reticularia. These preliminary papers have been principally devoted to the description of types, previously unknown, or at any rate little understood, presenting features of interest from a morphological stand-point. I propose to devote the present contribution chiefly to the consideration of questions connected with the classification of the group, supplementing what I have to say on this point by brief descriptions of a further instalment of new species, and a note on certain deposits, now in course of formation, in which the porcellanous group of Rhizopoda plays the most important part.

1. *Classification.*

Of the primary subdivision of the Class RHIZOPODA it is no part of my present purpose to speak; I intend rather to confine my observations to the Order to which my attention has been of late more particularly directed, and the subordinate groups into which its constituent organisms may best be arranged.

The term *Foraminifères* was originally employed by d'Orbigny in his scheme for the classification of the Mollusca, at a time when the Foraminifera, or at least a considerable section of them, were regarded as microscopic Cephalopods. In his "Tableau Méthodique,"¹ the Class

¹ 'Annales des Sciences Naturelles,' 1826, vol. vii, p. 245.

'IIIe Ordre.—FORAMINIFÈRES, Nob.; *Asiphonoïdes*, de Haan.

"*Charact. essent.*—Un test polythalamé totalement interne; dernière cloison terminale; point de siphon, mais seulement une ou plusieurs ouvertures donnant communication d'une loge à l'autre."

CÉPHALOPODES was divided into three orders,—I. *Cryptodibranches*; II. *Siphonifères*; III. *Foraminifères*; and of these the last two, which comprised Mollusca with chambered shells, were distinguished from each other by the *Siphonifères* having the septa traversed by a continuous tube, whilst in the *Foraminifères* the chambers communicated with each other by an aperture or foramen,¹ or by several such.

There is little in d'Orbigny's classification or in his definition of the Order that commends itself to the student of the present day, and it is even probable that the term "Foraminifera" is more commonly associated with the general perforation of the shell-wall, which is a conspicuous feature of a single group, than with the character it was originally designed to indicate; nevertheless, it is certain that no other name which has been suggested—whether *Rhizostomes*, *Simplectomères*, *Polypodes*, *Trematophores*, *Asiphonoïdes* or *Polythalamia*—has found the same acceptance amongst naturalists. The term *Polythalamia* has been adopted by Ehrenberg, in his voluminous treatises, and to some extent also by Max Schultze, but by others it has been seldom employed except as an alternative name; and it is open to the objection that, etymologically, it is scarcely applicable to an assemblage of organisms of which a not inconsiderable proportion are monothalamous.

It may be questioned whether our knowledge of the structure and life-history of the animals constituting the Order, as distinct from their tests, is sufficiently extensive for purposes of nomenclature—the number of arenaceous types, for example, concerning which we have any recorded observations on living specimens, is very small—but, so far as is known, the term "Rhizopoda Reticularia," suggested by Dr. Carpenter and accepted by Prof. F. E. Schulze and others, is perfectly appropriate.

At the same time we may remember that it is to d'Orbigny we owe the first recognition of the Foraminifera as a distinct zoological group, as well as the researches which gave the first impulse to their independent study, and, in absence of any weighty argument to the contrary, rule and custom alike suggest the acceptance of the name given by him and already generally adopted.

Prof. R. Hertwig, in the scheme of classification of the Rhizopoda, appended to his recent admirable memoir on the Radiolaria,² limits the application of the term Foraminifera,

¹ *Foramen* (Lat.), "an opening or hole produced by boring; an aperture."

² 'Der Organismus der Radiolarien,' by Dr. Richard Hertwig, 1879, p. 142.

so as to correspond with Dr. Carpenter's sub-order *Perforata*; but, as has been before stated, the term does not refer to general shell-perforation but to the existence of stoloniferous orifices, and in this sense it is equally true of all polythalamous forms whether otherwise "perforate" or "imperforate." Nor is there much violence to d'Orbigny's original idea in accepting the orifice of *Lagena*, or analogous types, as a "foramen," though, in the absence of a succession of chambers, it serves only for the passage of pseudopodia. On these grounds, therefore, either the term *Foraminifera*, derived from the shell or other investment, or *Reticularia*, suggested by the distinctive character of the sarcode-body, is a sufficiently accurate designation for the group.

The *Foraminifères*, treated as an Order of *Céphalopodes*, were divided in the 'Tableau Méthodique' (1826) into five families, based upon the mode in which the segments were combined to form the polythalamous shell. After the discovery of monothalamous forms like *Orbulina* and *Lagena*, and the recognition of cyclical types such as *Orbitolites*, two new families were constituted for their reception. In the meantime, however, the researches of Dujardin had made known the true nature of the organization of the Rhizopoda, and had necessitated the removal of the group to a lower position in the zoological scale. Hence in d'Orbigny's later works,¹ the *Foraminifères* constitute the 4th Class of ZOO-PHYTES (2nd Division, "*Zoophytes Globuleux*," placed between *Polypiers* and *Infusoires*), and are divided into seven orders with characters which may be briefly summarised as follows:

Order 1. MONOSTÈGUES. — Shell formed of a single chamber.

Order 2. CYCLOSTÈGUES. — Shell discoidal, composed of concentric lines of cells, simple or multiple; never spiral.

Order 3. STICHOSTÈGUES. — Shell formed of chambers joined end to end in a straight or curved line; never spiral.

Order 4. HELICOSTÈGUES. — Shell composed of chambers in a single series, spirally coiled.

Order 5. ENTOMOSTÈGUES. — Shell composed of chambers arranged in two alternating series and spirally coiled.

Order 6. ÉNALLOSTÈGUES. — Shell composed of chambers

¹ "Cours Élémentaire de Paléontologie et de Géologie Stratigraphiques," vol. ii, p. 189. Paris, 1852.

arranged alternately in two or three distinct axes, but not on a spiral plan.

Order 7. AGATHISTÈGUES.—Shell composed of chambers wound round a common axis, each forming half the circumference; texture smooth and imperforate.

Whilst there are certain advantages to be derived from a purely artificial arrangement—as, for example, the Linnean classification of plants—it is seldom that such a method can be adopted without violence in one way or other to manifest natural affinities, and the lowest divisions of the animal and vegetable kingdoms are perhaps least of all suited for its introduction. The chief difficulties that beset the student of systematic zoology, when engaged upon these low types of animal life, arise from the wide range of morphological variation he is obliged to admit within the limits assigned to species; and although there is a great difference in different genera as to the degree of persistence in the distinctive characters of their subordinate forms, it may be fairly doubted whether “species,” in the sense in which the word is rightly applied to animals of more complex organisation, can be said to exist amongst the lower Protozoa. It is only as we learn to recognise the fact that amongst the Rhizopoda the so-called “species” represent no more than terms of a series of which very frequently every intermediate link can be supplied, that we arrive at any just conception of their relationship. This being so, it is easy to see where a purely artificial classification must inevitably break down; and though the d’Orbignian scheme was a fair attempt to deal with a great mass of facts, collected by its author with infinite labour, it has now ceased to be of service, and has fallen into desuetude. Its defects are too obvious to need comment; it had none of that elasticity which gives to a system of classification the element of permanence, and which can only exist in proportion to the degree in which it is based upon natural affinity and the natural sequence of forms.

In the year 1854 Professor Max Schultze published his classical memoir, ‘Ueber den Organismus der Polythalamien (Foraminiferen),’ and with it an exposition of his views on the classification of the Rhizopoda. His conclusions, summarised in a convenient table at the end of the volume, are briefly as follows. The Rhizopoda are divided primarily into NUDA and TESTACEA, the former with the genus *Amœba* for its type, the latter embracing all the forms having an external shell or other investment. The TESTACEA are divided into two suborders—*Monothalamia* and *Polythalamia*—the one

subdivided into three families, the other into seven, and the principal genera, perhaps all that were then known, are distributed amongst these. Professor Max Schultze's scheme is characterised by a somewhat wider grasp of the subject than its predecessor; but with our present knowledge there is little to be said in favour of a classification that places *Orbulina* and *Lagena* in one of its two primary divisions, and *Globigerina* and *Nodosaria* in the other, or wherein *Nodosaria* and *Cristellaria* are to be found in different families. There was, in fact, no practical advantage to be derived from it, and, so far as I am aware, it has been accepted by no subsequent writer.

In the years 1861-2, practically simultaneously, appeared the memoirs containing the outlines of the two systems of classification which have been adopted, one or other of them, by the present generation of Rhizopodists. That Prof. von Reuss,¹ working on the Continent almost exclusively upon fossil specimens, and Dr. Carpenter with Professors Parker and Rupert Jones,² in this country, from the broader lines of the comparative study of living and fossil types, should have arrived independently at conclusions identical in their more important particulars, appears strong *primâ facie* evidence that a reliable foundation, whatever the superstructure, had been at length reached. These papers are still the standpoint from which the discussion of the subject must be commenced, and it is therefore necessary at the outset to state the general features of the schemes they embody, and by comparison, side by side, to show how far they agree in their details, and wherein they differ.

The basis of the primary divisions of both systems is the minute structure of the shelly investment—a ground of distinction hardly recognised by previous authors. In general terms Foraminifera are divided into the same two classes—those with non-porous or imperforate, and those with porous or perforate tests. The former of these two divisions (*Imperforata*) is in both systems subdivided into two sections, one including the types which have composite tests, that is, built up of sand-grains or similar extraneous bodies more or less embedded in calcareous cement, the other having opaque, porcellanous shells of fine texture.

In the division comprising the perforate or porous-shelled forms the agreement is less complete, as might be expected

¹ "Entwurf einer systematischen Zusammenstellung der Foraminiferen," 'Sitzungsb. k. Akad. Wiss.,' vol. xlv, p. 355. (The volume for the year 1861, published, I suppose, in 1862.)

² 'Introduction to the Study of the Foraminifera,' London, 1862.

with the larger number of types to be accommodated and the greater diversity in their characters; but even in this the two classifications have very much in common.

Their general relationship will be readily understood by the following comparative table:

VON REUSS.	CARPENTER, PARKER, AND JONES.
—	—
A. Foraminifera with non-porous tests.	Sub-order—Imperforata.
A. WITH ARENACEOUS TESTS.	Family—GROMIDA.
1. <i>Lituolidea</i> .	Family—LITUOLIDA.
2. <i>Uvellaidea</i> .	
B. WITH COMPACT, PORCELLANOUS, CALCAREOUS SHELLS.	Family—MILIOLIDA.
1. <i>Squamulinidea</i> .	
2. <i>Miliolidea</i> .	
3. <i>Peneroplidea</i> .	
4. <i>Orbitulitidea</i> .	
B. Foraminifera with porous shells.	Sub-order—Perforata.
A. WITH GLASSY, FINELY POROUS, CALCAREOUS SHELLS.	Family—LAGENIDA.
1. <i>Spirillinidea</i> .	
2. <i>Ovulitidea</i> .	
3. <i>Rhabdoidea</i> .	
4. <i>Cristellaridea</i> .	
5. <i>Polymorphinidea</i> .	
6. <i>Cryptostegia</i> .	
7. <i>Textilaridea</i> .	
8. <i>Cassidulinidea</i> .	
B. WITH EXCEEDINGLY POROUS, CALCAREOUS SHELLS.	Family—GLOBIGERINIDA.
1. <i>Rotalidea</i> .	
C. WITH CALCAREOUS SHELLS, TRAVERSED BY A RAMIFIED CANAL-SYSTEM.	Family—NUMMULINIDA.
1. <i>Polystomellidea</i> .	
2. <i>Nummulitidea</i> .	

Professor von Reuss's classification, above quoted, is taken from the "Postscript" to the memoir referred to, in which the primary division into "Foraminifera Monomera" and "Foraminifera Polymera," adopted in the body of the paper, is abandoned. His family *Gromidea* also, which corresponded with the GROMIDA of the English observers, is

omitted entirely in the revised scheme. In the correlation of the two classifications, the principal discrepancy occurs in the sub-order *Perforata*. The *LAGENIDA* and *GLOBIGERINIDA* together are almost exactly coextensive with Von Reuss's two sections *B*, *A* and *B*, but the (1) *Spirillinidea*, (2) *Ovulitidea*, (7) *Textilaridea*, and (8) *Cassidulinidea*, together with one or two genera from other groups, find place amongst the *GLOBIGERINIDA* of the British classification, and the family *LAGENIDA* is correspondingly reduced in extent. The family *NUMMULINIDA* corresponds exactly with Von Reuss's section *B*, *C*.

In his latest memoir¹ Von Reuss again somewhat modified his arrangement, making three primary groups of equal zoological value, and reversing the order originally adopted, thus:—*A. Kalkschalige Foraminiferen*, *B. Porenlose Foraminiferen*, *C. Kieselschalige Foraminiferen*; but its general features were left otherwise unchanged.

It will be seen at a glance that the "families" of the German arrangement are much smaller and more numerous than those adopted by the English naturalists, but this is counterbalanced by the more comprehensive "generic types" of the latter. The essential difference, not only between the two systems of classification, but in the entire methods of study and nomenclature, is to be found in the different values of their respective "genera" and "species."

Before proceeding to any further remarks upon these, we may notice briefly two other schemes of classification which have been suggested comparatively recently, one by Professor T. Rupert Jones,² the other by Professor Carl Zittel.³ Their general features will in like manner be best understood from tabular summaries.

¹ 'Das Elbthalgebirge in Sachsen,' 2ter Theil, 1874.

² 'Monthly Microscopical Journal,' No. 86, Feb., 1876, pp. 89—92.

³ 'Handbuch der Paläontologie,' vol. i, pt. 1, 1876, pp. 61—106.

RUPERT JONES.

Sub-order I. IMPERFORATA vel
PORCELLANA.

- Family I. *Nubecularida*.
- II. *Miliolida*.
- III. *Peneroplida*.
- IV. *Orbiculina*.
- V. *Dactyloporida*.

Sub-order II. ARENACEA.

- Family I. *Parkeriada*.
- II. *Lituolida*.

Sub-order III. PERFORATA vel
HYALINA.

- Family I. *Lagenida*.
- II. *Polymorphinida*.
- III. *Buliminida*.
- IV. *Textularida*.
- V. *Globigerinida*.
 - (1) *Globigerinina*.
 - (2) *Rotalina*.
 - (3) *Polystomellina*.
 - (4) *Nummulina*.

ZITTEL.

Sub-order I. IMPERFORATA.

- Family I. *Gromidæ*.
- II. *Cornuspiridæ*.
- III. *Miliolidæ*.
- IV. *Dactyloporidæ*.

Sub-order II. PERFORATA.

- Family I. *Lagenidæ*.
- II. *Globigerinidæ*.
 - (1) *Globigerinæ*.
 - (2) *Textularinæ*.
 - (3) *Rotalinæ*.
- III. *Nummulinidæ*.

The primary division of Foraminifera into *Perforata* and *Imperforata* would be very convenient if it could be employed in its original sense; but it is now well known that some, though perhaps not a large proportion, of the arenaceous types, have interstitial openings amongst the sand-grains of which the test is built, in addition to the general aperture: that others, like *Psammosphæra* and *Sorosphæra*, have no general aperture, but only interstitial orifices; whilst a few, *Thurammia*, for example, have numerous small mammillate orifices, irregularly disposed over the surface of the test, either with or without a general aperture. If the arenaceous group be removed from the *Imperforata* there remain but the chitinous and porcellanous forms. Rupert Jones follows Von Reuss in making a distinct sub-order of the *Arenacea*, and, as he entirely omits the chitinous group, his sub-order *Imperforata* is exactly co-extensive with Dr. Carpenter's family *Miliolida*. Professor Zittel, on the other hand, only admits arenaceous structure as a character of secondary importance, and distributes the sandy forms amongst the porcellanous, so that types as diverse as *Saccammia* and *Cornuspira*, or as *Miliola* and *Botellina*, are found in the same family.

That the *Porcellanea* are, under all circumstances, imper-

forate, I have convinced myself by observations extending over many years, and that a large proportion of the *Arenacea* are likewise imperforate I fully believe; but the exceptions in the latter case are so numerous and varied, that the arenaceous group cannot be included as a whole in a sub-order of which the distinctive character is the imperforate test, and if omitted the term becomes at once misleading; therefore it is manifestly better to abandon a primary subdivision based solely on the condition of the investment in respect to perforation.

The adoption of three sub-orders, instead of two, depending on shell-texture rather than on mere perforation, as latterly proposed by Von Reuss and adopted by Rupert Jones, meets the difficulty in part, but is still open to objection. On the one hand there is a considerable group of true *Miliolæ*, our knowledge of which is much extended by the "Challenger" collections, that have rough arenaceous tests; and on the other, the large and important family *Textularidæ* is practically unprovided for, inasmuch as it is sometimes truly arenaceous, sometimes hyaline and perforate, and sometimes externally sandy but with an inner perforate shell. Von Reuss meets this difficulty by dividing certain genera and placing the two halves in different sub-orders; thus *Textularia* appears as *Textularia* amongst the hyaline forms and as *Plecanium* amongst the arenaceous, and *Bulimina* in the same way as *Bulimina* and *Ataxophragmium*; but this is cutting the knot rather than untying it, and even were so summary a method practically convenient, the proposal to divide a natural group like that comprising the Textularian and Bulimine types in order to meet the exigencies of an artificial distinction, is not one to be lightly adopted.

Passing from sub-orders to families, even greater anomalies are apparent in Von Reuss's scheme, especially amongst the hyaline forms. For example, *Spirillina* is found at almost the opposite end of the scale to the Rotaline genera; *Nodosaria*, *Cristellaria*, and *Polymorphina* are placed in separate families, whereas, in point of fact, they form an absolutely continuous series; and *Textularia*, *Bulimina*, and *Cassidulina* are similarly separated. These appear to me fatal objections to the details of the classification.

In the collateral English arrangement there is no infringement of natural relationship apparent in the constitution of the families, except, perhaps, the association of *Textularia* and its immediate allies with *Globigerina* and the Rotaline genera. Apart from this, its chief drawback is that the divisions are too large to be zoologically convenient.

The families proposed by Rupert Jones in his redivision of the sub-orders, with a view to remedying this defect, hardly meet our present requirements. Of Professor Zittel's classification I have had occasion to speak elsewhere¹ at some length, and I have nothing to modify in the views expressed at the time of its publication as to its merits and shortcomings.

Every attempt to arrange in single series a class of organisms of which the constituent groups run sometimes in several parallel lines, or even form independent circlets, morphologically speaking, is of necessity open to objection at one point or other, and the aim of the systematist may be regarded as attained if the anomalies and inconsistencies are slight, and are confined to particulars of the smallest zoological importance. In the scheme which I now venture to propose I have endeavoured to embody the views already in part expressed. In one or two not unimportant points it differs from that originally devised by my friends Dr. Carpenter and Professors Parker and Rupert Jones, but in its essential elements there is little or nothing that is incompatible with the conclusions they have so ably expounded. It is put forward in outline, and with no pretence of completeness, in the hope that it may receive the criticism of naturalists whose pursuits qualify them to deal with the subject. The tabular summary needs, for the most part, but little explanation; the reasons for the course pursued, where it differs from that of other writers, are sufficiently obvious; but there are a few points in which the method of treatment has been dictated by the study of the "Challenger" collections, and the further exposition of these must be left until it can be made with the assistance of the plates of the memoir now in progress. The nature of the investment of the animal—in other words, the texture of the test—has been to a certain extent abandoned as a primary distinction, though it is still employed in a modified way. Under all circumstances it is an important character, and in some families is distinctive; but it will be seen that whilst there are certain families which are invariably arenaceous, and others which are invariably calcareous and perforate, there are some in which no uniform rule obtains.

A. *Test imperforate, chitinous.*

I. GROMIDÆ.—There has been much difference of opinion as to the zoological position of *Gromia* and its allies. So long as the animal of the Foraminifera was supposed to be

¹ 'Nature,' Sept. 21st, 1876, vol. xiv, p. 445.

mere undifferentiated protoplasm, *Gromia* might properly be regarded as pertaining to a higher type of organisation; but recent researches, notably those of Professor R. Hertwig and Professor F. E. Schulze, have shown that certain types of Foraminifera possess nuclei indistinguishable from analogous bodies in the chitinous fresh-water Rhizopods. Professor Leidy, in his elaborate work upon the 'Fresh-water Rhizopods of North America,' just published, practically confirms this view by treating *Gromia* as a genus of Foraminifera.

B. *Test imperforate; normally porcellanous, sometimes encrusted with sand; under starved conditions (e.g. in brackish water) becoming chitinous or chitino-arenaceous; at abyssal depths occasionally consisting of a thin homogeneous, imperforate, silicious film.*

II. MILIOLIDÆ.—Concerning the genus *Squamulina* there seems still considerable doubt. Judging from Max Schultze's description and figures it seems to be a monothalamous, adherent, porcellanous species, not far removed from the simpler varieties of *Nubecularia*.

Of the *Dactyloporinæ* there is little to be said at the present time inasmuch as they may have to be removed, either entirely or in part, to the calcareous *Algæ*; but as yet we have no authority for so important a step beyond the brief preliminary notice of M. Munier-Chalmas's researches, and it will be generally admitted that there are two sides to the question.

C. *Test invariably arenaceous.*

III. ASTRORHIZIDÆ.—Coarse sandy forms, usually of large size, and monothalamous; often branched or radiate, but never truly septate (*i. e.* as distinct from mere constriction). Polythalamous forms never symmetrical.

It is probably that this family may eventually require subdivision; as now proposed it includes all the deep-water arenaceous recent Rhizopods except those of the family *Lituolidæ*.

IV. LITUOLIDÆ.—Comprises sandy isomorphs of the simpler hyaline types (*Lagena*, *Nodosaria*, *Globigerina*, *Rotalia*, *Nonionina*, &c.), together with some adherent species. Septation of the polythalamous forms imperfect; chambers sometimes subdivided or labyrinthic.

V. PARKERIDÆ.—Large, spherical, lenticular, or fusiform fossils; constructed either on a spiral plan or in concen-

tric layers; the chambers occupied to a great extent by labyrinthic or cancellated shelly growths.

For the present I know of no more appropriate place than this for *Parkeria*, *Loftusia*, and their immediate allies. It may be admitted that we have still a great deal to learn concerning them, and should the *Stromatoporidæ* be proved eventually to occupy an intermediate position, related on the one side to Rhizopods, on the other to Sponges, possibly these types may find their proper place as a further connecting link on the Rhizopod side.

D. *Tests of the larger species arenaceous, either with or without a perforate, calcareous basis; smaller forms hyaline and conspicuously perforated.*

VI. TEXTULARIDÆ.—I can see no advantage in the attempt to separate the arenaceous *Textulariæ* and *Buliminæ* from the clear-shelled species, but much the contrary; nor can I recognise any valid distinction, of more than secondary importance, between *Textularia* and *Valvulina*.¹

E. *Test calcareous, finely perforate.*

VII. CHILOSTOMELLIDÆ.—With Reuss's genera *Chilostomella* and *Allomorphina*, which together form his family *Cryptostegia*, I have associated Seguenza's genus *Ellipsoidina*. The anomalous characters of the latter, viewed as a Nodosarian, I pointed out many years ago, and had I then known the genus *Chilostomella* by anything more than figures, I should have suggested the present position for it. The primary difference in the structure of these two types consists in the fact that in *Chilostomella* the segments alternate, the attachment to each other being at one side, and the aperture first at one end and then at the other, whilst in *Ellipsoidina* the attachment is at the base, the segments grow in the same direction, and consequently the aperture is always at the same end.

VIII. LAGENIDÆ.—This is exactly coextensive with the *Lagenida* of Messrs. Carpenter, Parker, and Jones.

F. *Test calcareous, generally very coarsely perforated, no trace of canal-system.*

¹ I arrived at this conclusion originally from the study of the Carboniferous types of Rhizopoda; meanwhile my friend Mr. Carter had come to the same result, from working on recent species. *Vide*, 'Ann. and Mag. Nat. Hist.,' ser. 4, vol. xix, p. 205. The close affinity of *Textularia* with *Valvulina* is fully recognised by Dr. Carpenter and his colleagues ('Introd.,' p. 192), though the two genera are widely separated in their scheme of classification.

IX. GLOBIGERINIDÆ.—A compact group of essentially pelagic types. With the exception of a few species, generally of small size, all have been found living in open sea, at or near the surface.

G. *Test coarsely perforate, a few of the higher forms with double chamber-walls and interseptal canals.*

X. ROTALIDÆ.—Embraces the *Rotalinæ* of Messrs. Carpenter, Parker and Jones, with the addition of the genus *Spirillina*, which may be regarded as their non-septate modification, just as *Cornuspira* is a non-septate *Miliola* and *Ammodiscus* a non-septate *Trochammina*.

H. *Test very finely tubulated. All the higher types possessing a system of interseptal canals of greater or less complexity.*

XI. NUMMULINIDÆ.—Coextensive with the *Nummulinida* of Carpenter, Parker and Jones. I have retained *Fusulina* in the place hitherto assigned to it, on the ground of its symmetrical contour, but, as Dr. Carpenter has shown, the genus has almost as much in common with the *Rotalidæ*.

CLASS—RHIZOPODA, Dujardin.

Order—FORAMINIFERA, d'Orbigny—(RETICULARIA, Carpenter).

FAMILY I. GROMIDÆ.—*Gromia*, Dujardin; *Lagynis*, Schultze; *Lieberkuhnia*, Claparède; *Shepherdella*, Siddall.

FAMILY II. MILIOLIDÆ.

- a. *Miliolininæ*.—*Bathysiphon*, G. O. Sars; *Squamulina*, Schultze; *Nubecularia*, Defrance; *Uni-*, *Bi-*, *Spiroloculina*, d'Orbigny; *Miliolina*, Williamson; *Cornuspira*, Schultze (*Ophthalmidium*, Kübler); *Hauerina*, d'Orbigny; *Vertebralina*, d'Orbigny (*Articulina*, d'Orbigny); *Fabularia*, Defrance.
- β. *Orbitolitinaæ*.—*Peneroplis*, de Montfort; *Orbiculina*, Lamarck; *Orbitolites*, Lamarck; *Alveolina*, d'Orbigny.
- γ. (?) *Dactyloporinaæ*.—*Ovulites*, Lamarck; *Dactylopora*, Lamarck, and sub-genera.

FAMILY III. ASTRORHIZIDÆ.—*Psammosphæra*, Schulze; *Sorosphæra*, Brady; *Saccamina*, M. Sars; *Pilulina*, Carpenter; *Storthosphæra*, Schulze; *Technitella*, Norman; *Pelosina*, Brady; *Aschemonella*, Brady; *Astrorhiza*, Sandahl; *Dendrophrya*, Str. Wright; *Rhabdammina*, M. Sars; *Jaculella*, Brady; *Hyperammina*, Brady; *Psammatodendron*, Norman (Ms); *Sagenella*, Brady; *Botellina*, Carpenter; *Marsipella*, Norman; *Haliphysema*, Bowerbank; *Polyphragma*, Reuss.

FAMILY IV. **LITUOLIDÆ**.—*Lituola*, Lamarck (*Reophax*, de Montfort; *Haplophragmium*, Reuss; *Haplostiche*, Reuss; *Placopsilina*, d'Orbigny; *Bdelloidina*, Carter); *Trochammina*, Parker & Jones (*Hormosina*, Brady; *Ammodiscus*, Reuss; *Webbina*, d'Orbigny); *Nodosinella*, Brady; *Involutina*, Terquem; *Endothyra*, Phillips; *Stacheia*, Brady; *Thurammina*, Brady; *Hippocrepina*, Parker; *Cyclammina*, Brady.

FAMILY V. **PARKERIDÆ**.—*Parkeria*, Carpenter; *Loftusia*, Brady.

FAMILY VI. **TEXTULARIDÆ**.

- a.* **Textularinæ**.—*Textularia*, Defrance (*Bigenerina*, d'Orbigny; *Pavonina*, d'Orbigny; *Spiroplecta*, Ehrenberg; *Cuneolina*, d'Orbigny); *Verneuilina*, d'Orbigny (*Gaudrynia*, d'Orbigny; *Chrysalidina*, d'Orbigny; *Tritaxia*, Reuss); *Valvulina*, d'Orbigny (*Clavulina*, d'Orbigny).
β. **Bulimininæ**.—*Bulimina*, d'Orbigny (*Virgulina*, d'Orbigny; *Bolivina*, d'Orbigny; *Pleurostomella*, Reuss).
γ. **Cassidulininæ**.—*Cassidulina*, d'Orbigny; *Ehrenbergina*, Reuss.

FAMILY VII. **CHILOSTOMELLIDÆ**.—*Chilostomella*, Reuss; *Allo-morphina*, Reuss; *Ellipsoidina*, Seguenza.

FAMILY VIII. **LAGENIDÆ**.

- a.* **Lageninæ**.—*Lagena*, Walker & Jacob; *Ramulina*, Jones; *Nodosaria*, Lamarck (*Lingulina*, d'Orbigny); *Fron-dicularia*, Defrance (*Flabellina*, d'Orbigny); *Vaginulina*, d'Orbigny (*Rimulina*, d'Orbigny; *Rhabdogonium*, Reuss); *Marginulina*, d'Orbigny; *Cristellaria*, Lamarck.
β.—**Polymorphininæ**.—*Polymorphina*, d'Orbigny (*Dimorphina*, d'Orbigny); *Uvigerina*, d'Orbigny (*Sagrina*, d'Orbigny).

FAMILY IX. **GLOBIGERINIDÆ**.—*Globigerina*, d'Orbigny (*Orbulina*, d'Orbigny); *Hastigerina*, Wy. Thomson; *Pullenia*, Parker & Jones; *Sphæroidina*, d'Orbigny; *Candeina*, d'Orbigny.

FAMILY X. **ROTALIDÆ**.—*Spirillina*, Ehrenberg; *Patellina*, Williamson; *Discorbina*, Parker & Jones, *Planorbulina*, d'Orbigny (*Truncatulina*, d'Orbigny; *Anomalina*, d'Orbigny); *Rupertia*, Wallich; *Carpenteria*, Gray; *Polytrema*, Risso; *Tinoporus*, de Montfort (*Gypsina*, Carter); *Cymbalopora*, v. Hagenow; *Pulvinulina*, Parker & Jones; *Rotalia*, Lamarck; *Calcarina*, d'Orbigny.

FAMILY XI. **NUMMULINIDÆ**.

- a.* **Polystomellinæ**.—*Nonionina*, d'Orbigny; *Polystomella*, Lamarck.
β. **Nummulitinæ**.—*Archædiscus*, Brady; *Amphistegina*, d'Orbigny; *Fusulina*, Fischer; *Eozöon*, (?) Dawson; *Orbitoides*, d'Orbigny; *Cycloclypeus*, Carpenter; *Heterostegina*, d'Orbigny; *Operculina*, d'Orbigny; *Nummulites*, Lamarck.

2. *Further notes on New Species.*

It is at all times difficult to devise concise zoological descriptions that shall be intelligible without the aid of figures, hence in the selection of a third instalment of new forms for publication, those with peculiarities most readily indicated by verbal characters have been preferred. As a matter of fact, figures of all the forms about to be enumerated have long since been drawn, and most of them are included in plates already lithographed by Mr. Hollick; but unfortunately the time required for the completion of so large a series of illustrations still delays the progress of the work for which they are intended. The object of the following notes is to furnish brief distinctive characters, sufficient for the recognition of the various species, without entering upon any detailed account of their structure or distribution.

BILOCULINA, d'Orbigny.

Biloculina comata, nov.—General characters similar to those of the typical *B. ringens*, but having a surface ornamentation of close, regular, longitudinal, raised striæ. Specimens often attain a very large size, especially in the North Atlantic.

MILIOLINA, Williamson.

Miliolina insignis, nov.—Has the same morphological characters as *M. trigonula*, but the surface is covered with delicate longitudinal costæ. Specimens often of large size.

M. cultrata, nov.—Test Triloculine, depressed; segments long, narrow, biconvex; superior end of the final chamber projecting far beyond the base of the penultimate; peripheral margin furnished with a continuous narrow keel or wing. Length, $\frac{1}{30}$ inch (0·8 mm.).

M. transversestriata, nov.—A minute, elongate, angular, Triloculine variety, with the peripheral margins of the chambers sharp or subcarinate, and the surface marked by regular, parallel, transverse or diagonal riblets or striæ. Length, $\frac{1}{50}$ inch (0·5 mm.).

M. separans, nov.—Test irregular in form, angular, outspread; consisting of several long, slightly inflated, strongly costate, Milioline segments; the earlier segments arranged on the normal plan, the later ones centrifugally, that is to say, at irregular angles, as though in process of uncoiling. Length, $\frac{1}{10}$ inch (2·5 mm.) or sometimes more.

- M. Rupertiana*, nov.—Test elongate, biconvex and Triloculine in the young condition, Quinqueloculine and depressed in the adult; peripheral margin rounded, in very old specimens thin or carinate. Final segment terminating in an oval collar, either continuous and regular, or with a deep notch at each end (bilabiate), or with four equidistant notches forming a sort of cruciate aperture. Surface, striatopunctate, *i. e.* with minute pits or depressions in close, regular, parallel lines from one end of the test to the other. The test nevertheless is imperforate, for the pitted depressions penetrate only about half the thickness of the shell-wall. Length, $\frac{1}{13}$ inch (1.9 mm.).
- M. Parkeri*, nov.—This form is figured by Professor W. K. Parker in one of his earliest papers,¹ where it is simply characterised as a “*Quinqueloculina* with oblique ridges,” but without distinctive name. The test is elongate and subtriangular; the peripheral margins of the segments sharp, with a tendency to become carinate; their surfaces traversed by somewhat oblique transverse ridges or crenulations. Length, $\frac{1}{25}$ inch (1 mm.).
- M. incrassata*, nov.—A thick subglobular form of *M. agglutinans*, very coarsely arenaceous in texture. Segments embracing, with a tendency to become Biloculine (as in *B. contraria*), septation obscure. Aperture crescentic, situate in a short delicate neck rising from the superior extremity of the final segment. Length, $\frac{1}{33}$ inch (0.76 mm.).

HAUERINA, d'Orbigny.

Hauerina borealis, nov.—Test planospiral, orbicular, compressed, biconvex; margin thick and rounded, very little hollowed at the sutures. Composed of several convolutions, the latter ones consisting of from three to five long narrow chambers. Aperture, simple crescentiform, situate on the face of the terminal segment a little removed from the line of junction with the previous convolution by a small erect lip. Diameter, $\frac{1}{20}$ inch (1.3 mm.).

This thick lenticular form of *Hauerina* appears to be limited in its distribution to the North Atlantic, and under the name of *H. compressa* it has been recorded

¹ “On the Miliolitidæ (*Agathistegues*, d'Orbigny) of the East Indian Seas,” part I, “Miliola,” ‘*Trans. Micros. Soc.*,’ London, 1858, vol. vi, N.S., p. 53, pl. 5, fig. 10.

from the west coast of Scotland.¹ At times it is not easily distinguished from *Biloculina contraria*, for the internal structure is obscured by the thickness and opacity of the test; generally, however, there are slight constrictions or depressions at the periphery, marking the sutures.

H. circinata, nov.—Test nautiloid, thin, complanate; composed of two or three convolutions, the last, consisting of six or seven segments, completely enclosing the earlier ones. Segments arched, rounded at their peripheral margins; sutural lines marked by external constrictions. Colour milky white, sufficiently translucent to show the outline of the inner whorl of chambers. Aperture consisting of a number of perforations distributed irregularly over the front of the terminal segment. Diameter $\frac{1}{25}$ inch (1 mm.).

ORBITOLITES, Lamarck.

Orbitolites laciniatus, nov.—A variety of *Orbitolites* of the complex type, figured by Carpenter ('Phil. Trans.,' 1856, pl. 5, figs. 2, 3), and by Butschli (in Bronn's 'Klassen und Ordnungen des Thier-Reichs,' 1880, vol. i, pl. 5, fig. 4), but in both cases without name. It is little more than a local variety of *Orbitolites complanatus*, abundant on the coral reefs of the Friendly Islands and Fiji; but as it represents the best development of the structural modifications induced by redundant growth, it is convenient that it should be distinguished by name.

The centre of the disc is constructed on the normal plan, but near the margin it becomes strongly sinuate or plicate, at the same time splitting so as to form a double periphery, the two edges of which approximate at intervals, but otherwise are separated by deep irregular furrows. Specimens from the localities above-named are not unfrequently an inch (25 mm.) or more in diameter.

ASTRORHIZA, Sandahl.

Astrorhiza crassatina, nov.—Test (typically) elongate, sub-cylindrical, seldom of uniform breadth, often constricted near the middle, ends rounded; consisting of a tube of greater or less length open at both ends. Walls very

¹ "Rhizopodal Fauna of the Hebrides," 'Report Brit. Ass.,' 1866 (Trans. Sections), p. 69.

thick, composed of fine sand with but little cement. Cavity tubular, never of uniform diameter, but swollen at one or more points so as to form spurious chambers. Length about $\frac{1}{10}$ inch (10 mm.).

This form is nearly allied to *Astrorhiza granulosa* (*Marsipella granulosa*, 'Quart. J. Micr. Sci.,' vol. xix, n.s., p. 36, pl. 3, figs. 8, 9), and is perhaps its North Atlantic representative; but *A. granulosa* is of smaller dimensions, and the chamber-cavity consists of a narrow tube of even diameter throughout.

A. angulosa, nov.—Test triangular (rarely quadrangular), depressed, biconvex, with rounded margin; consists of a central chamber with radiating tubes, one passing to each corner, the open ends of which serve as apertures. Walls relatively very thick, and composed of loosely cemented fine sand. Diameter, $\frac{1}{7}$ inch (3.6 mm.).

A. angulosa appears to be a short, three-mouthed variety of *A. granulosa*, with which species it is found associated. In both of these, as also in *A. crassatina*, the orifices are often partially blocked with sand-grains, and not unfrequently are stained reddish brown.

RHABDAMMINA, Sars.

Rhabdammina discreta, nov.—Test cylindrical, open at both ends; consisting of a straight or nearly straight tube of indefinite length, spuriously segmented by slight constrictions at irregular intervals. Walls thin, composed of angular sand-grains firmly cemented; interior smooth. Specimens nearly an inch (25 mm.) in length are not uncommon.

BOTELLINA, Carpenter.

Botellina labyrinthica, nov.—Test arenaceous, cylindrical (probably growing attached by one end), straight, or slightly curved, somewhat irregular in external contour; one end round and more or less inflated, the other never hitherto found entire. The wall is of firm consistence and compactly built, except at the rounded extremity where it becomes a thin incomplete layer of sand grains with many interstitial openings. The interior, except near the rounded end, is subdivided irregularly by a labyrinth of coarse, sandy, spurious septa. The rounded terminal cavity forms an undivided chamber. Pieces hitherto obtained have seldom measured more than an inch (20 to 25 mm.), but it

is impossible to say what length complete specimens may attain. The diameter is about $\frac{1}{10}$ inch (2.5 mm.).

REOPHAX, de Montfort.

Of the monothalamous and moniliform (*Lagena*-like and *Nodosaria*-like) *Lituolæ* there are half a dozen unrecorded modifications of sufficient interest to deserve preliminary notice.

Reophax ampullacea, nov., is monothalamous and compressed. It bears very much the same relation to *R. difflugiformis* that *Lagena marginata* bears to *L. globosa*. Length, $\frac{1}{30}$ inch (0.85 mm.).

R. bacillaris, nov., is a long, regularly tapering, slightly arcuate variety, with very numerous, short segments. The earlier segments are cylindrical, and have flush sutures not distinguishable on the exterior, the later ones sub-spherical. Colour very dark. Length sometimes nearly $\frac{1}{5}$ inch (4.7 mm.).

R. rudis, nov.—The largest species of the subgenus hitherto met with. Shape long, cylindrical, slightly tapering; sides even and unconstricted; extremities rounded. The walls thicker than those of its congeners and of looser texture; composed of fine grey sand. A longitudinal section reveals about six segments, each tapering at the summit to a stoloniferous tube, the mouth of which, as well as the external orifice, is tinted reddish brown. Length, $\frac{1}{10}$ inch (10 mm.) or more.

The Rev. A. M. Norman has placed in my hands some specimens of a form which, though certainly distinct, is very difficult to separate from this by any positive characters. The specimens are of smaller size and relatively long and slender, darker in colour, and more compactly built; but neither they nor those of the larger species show any sutural constriction or other external mark of segmentation.

R. dentaliniformis, nov.—A small, delicate variety of *R. scorpiurus*, but more slender and regular in contour; segments five or six in number, elongate, and but slightly ventricose. Length, $\frac{1}{4}$ inch (1.85 mm.).

R. guttifera, nov., has pyriform segments, broadest near the base, and tapering to a narrow stoloniferous tube at the point of union with the succeeding chamber. In small specimens the base of the segments is often truncate or even somewhat concave. Number of segments very variable. Length, seldom exceeding $\frac{1}{16}$ inch (1.5 mm.).

R. distans, nov.—A thin-shelled, dark-coloured form, never found entire. Segments distinct, fusiform, tapering nearly equally at the two ends into stoloniferous tubes, which are long and slender in proportion to the bulk of the chambers they unite. Specimens with three chambers, which are the largest hitherto found, have a length of nearly $\frac{1}{5}$ inch (4·8 mm.).

HAPLOPHRAGMIUM, Reuss.

Of the section embracing the nautiloid, crozier-shaped and rotaliform *Lituolæ*, there are amongst the “Challenger” collection five species distinct from any hitherto described, in addition to several that may be left for the present as more or less doubtful.

Haplophragmium foliaceum, nov., has a very beautiful and delicate, crozier-shaped test, flat on both sides, and so thin as to be almost transparent. The segments are numerous, short and broad, and the peripheral margin is slightly constricted at the sutures. Length, $\frac{1}{6}$ inch (1·3 mm.).

H. rotulatum, nov.—A sandy isomorph of *Anomalina coronata*, nautiloid in contour and biconcave; the umbilicus is deeply sunk on both faces, and the periphery broad and square, often somewhat oblique. Diameter, $\frac{1}{40}$ inch (0·6 mm.) or less.

H. scitulum, nov.—Test nautiloid, excavated at the umbilicus, rounded at the periphery; composed of two to three convolutions, the outermost consisting of from eight to eleven segments only partially enclosing the earlier ones. Segments compactly fitted, with little or no depression at the sutural lines. Shell-wall finely arenaceous, nearly smooth externally, and of clear yellow-brown colour. Diameter, $\frac{1}{30}$ inch (0·8 mm.).

H. turbinatum, nov.—Test rotaliform, subglobular, depressed at the umbilicus; consisting of less than two convolutions. Segments somewhat ventricose; numbering about six in the peripheral whorl. Diameter, $\frac{1}{35}$ inch (0·75 mm.).

This form resembles *H. subglobosum* in size and texture, but differs from it in being rotaliform and unsymmetrical, not nautiloid.

H. nanum, nov.—Test minute, rotaliform, depressed; superior face somewhat convex; inferior, plane, more or less excavated at the umbilicus; margin rounded, lobulate. Consists of about two revolutions, each composed of

about six inflated segments, often irregular in shape and disposition. Shell texture thin, resembling that of *H. canariense*. Diameter, $\frac{1}{75}$ inch (0.34 mm.).

PLACOPSILINA, d'Orbigny.

There is, in addition, one simple adherent Lituoline species resembling in form the *Squamulina* of Max Schultze, but arenaceous instead of porcellanous in texture.

Placopsilina bulla, nov.—Test adherent; highly convex or approximately hemispherical but slightly longer in one diameter than the other; with a simple, rounded, pouting aperture at each end, close to the base. Walls thick, somewhat loosely sandy. Diameter, $\frac{1}{35}$ inch (0.75 mm.).

AMMODISCUS, Reuss.

Of the free non-septate *Trochamminæ* only two forms require present notice; both are somewhat remarkable for their size.

Ammodiscus tenuis, nov., is a large, thin, planospiral variety, consisting of a few broad, somewhat overlapping, convolutions. It bears the same relation to *A. incerta* that *Cornuspira foliacea* bears to *C. involvens*. Diameter, sometimes $\frac{1}{8}$ inch (3 mm.).

A. spectabilis, nov.—By far the largest species of the non-septate group, is composed of a tube wound upon itself, not regularly and symmetrically so as to retain a rectilinear shape (like *A. Shoneanus*), but in curved or twisted fashion, so as to form an arcuate or subhelicoid test. The shell-wall is very thin, the exterior somewhat rougher than usual amongst the *Trochamminæ*, the interior smooth and polished. Diameter, $\frac{1}{5}$ to $\frac{1}{4}$ inch (5 to 6 mm.).

HORMOSINA, Brady.

The following are representatives of the uniserial or moniliform section of the genus:

Hormosina Carpenteri, nov.—A fine species figured by Dr. Carpenter in his treatise on the 'Microscope' (5th ed., 1875, p. 531, fig. *f*), under the general name "Moniliform *Lituola*," pretty common in deep water in the North Atlantic and elsewhere. It consists of numerous, elongate, pyriform segments, increasing but slightly in size as they succeed each other; connected end to end in a curved or crooked, never (as a rule) in a straight line.

The shell-wall is finely arenaceous, compactly cemented, and nearly smooth on both its inner and outer surface, except when irregularity of the exterior is produced by sponge spicules only partially incorporated. Length, $\frac{1}{2}$ inch (13 mm.) or even more.

H. monile, nov.—A variety with similar general characters to that last described, but differing in its comparatively small dimensions and in the form of its segments. The segments are short, subspherical, and uniform in size. The length of the longest specimen hitherto obtained is about $\frac{1}{4}$ inch (6 mm.).

H. Normani, nov., has an irregularly constructed test composed of few spherical segments, of which the earlier ones are relatively small, the final one usually very large. The orifice is seldom at the apex of the chambers, but often at some point of the periphery, very near to the entrance of the last stoloniferous tube, so that the new segment is sometimes put on obliquely, sometimes at right angles to the previous one, or even, as is not unfrequently the case, directed backwards, as a result of which, the test assumes a great variety of irregular forms. Length, $\frac{1}{3}$ inch (8.5 mm.).

TROCHAMMINA, Parker & Jones.

Of the nautiloid and rotaliform *Trochamminæ* only two minute species require notice, in addition to those described in a former paper.

Trochammina galeata, nov.—Test nautiloid and symmetrical, subglobular or compressed, showing only three segments externally, of which the final one constitutes much more than half the visible shell. Aperture situated on the peripheral face of the final segment, near its junction with the antepenultimate; simple, often immediately below a projection of the shell-wall. Diameter, $\frac{1}{50}$ inch (0.5 mm.).

This species resembles *Tr. ringens*, described in a former paper ('Quart. Journ. Micr. Sci.,' vol. xix, N. S., p. 57, Pl. 5, fig. 12 *a, b*), in many particulars, but it is scarcely so large, and is relatively thicker; its few segments, and the disproportionate size and embracing contour of the final chamber, are sufficiently distinctive.

Tr. nitida, nov.—Test regular, rotaliform, compressed, superior face nearly flat; inferior convex, somewhat excavated at the umbilicus; margin rounded, slightly

depressed at the sutures. Consists of two to three convolutions, of which the final one has about nine segments. Diameter, $\frac{1}{50}$ inch (0.5 mm.).

CYCLAMMINA, Brady.

The genus *Cyclammina* is of considerable importance, inasmuch as it presents the best development amongst living Foraminifera, of finely tubular cancellated growths of shell substance filling the chamber cavities—a sort of structure differing widely from the mere subdivision of the chambers by the building in of large sand-grains, which is not uncommon amongst arenaceous types. There are two interesting modifications of *C. cancellata* amongst the “Challenger” gatherings, which, though perhaps only local varieties, differ sufficiently from the typical form to deserve distinctive names.

Cyclammina orbicularis, nov.—A subglobular variety, bearing about the same morphological relation to the type that *Nonionina pompilioides* does to *N. depressula*, only that it is of much smaller size.

C. pusilla, nov., has a minute, biconvex test, depressed at the umbilici, and with thin, sharp, slightly lobulate periphery. A horizontal section shows that it consists of about three complete convolutions, the last of which has about fifteen segments. The cancellated structure is but little developed, there being only sufficient to form a superficial reticulation over the inner surface of the chamber walls. Diameter, $\frac{1}{25}$ inch (1. mm.).

TEXTULARIA, Defrance.

Textularia siphonifera, nov.—Test subcylindrical, nearly round in transverse section, tapering and pointed at the primordial end; each of the two opposing series of chambers furnished with from two to four rows of tubulated fistulose openings, arranged with more or less regularity. Length, $\frac{1}{16}$ inch (1.5 mm.).

BIGENERINA, d'Orbigny.

Bigenerina robusta, nov.—Test elongate, compressed in its earlier (biserial) portion, cylindrical in its later (uniserial) growth. Uniserial segments numerous, short, somewhat irregular, often ventricose at their periphery. Aperture simple and Textularian in the biserial segments, becoming multiple and porous in the uniserial portion; the pores either arranged in a ring or irregu-

larly distributed in the central part of the exposed face of the terminal chamber. Interior non-labyrinthic. Length, about $\frac{1}{5}$ inch (4·8 mm.).

This species is of much interest in its bearing upon a group of Carboniferous Foraminifera which have been a source of difficulty to palæontologists. The fossils alluded to were described by myself some years ago under the provisional generic name *Climacammina*,¹ and since that time similar specimens from the Russian Carboniferous beds have been figured by Prof. von Möller with the fresh generic term *Cribrostomum*.² The characters of most, if not of all the fossil specimens, have been a good deal obscured by external agencies, such as pressure and the process of mineralisation, but they are easily recognised in the presence of the recent examples which we now have for comparison; indeed, it is not altogether easy to find positive features whereby to distinguish the palæozoic from the living species. Throughout the whole genus *Textularia* the aperture is one of the most variable features, and as the only conspicuous point in which the dimorphous forms under consideration differ from the typical *Bigenerina* is in the fact that their later segments have a porous instead of the usual simple aperture, I can see nothing to be gained by employing a distinctive generic or subgeneric name for them.

CHRYSALIDINA, d'Orbigny.

Chrysalidina dimorpha, nov.—Test elongate, triangular, tapering; the three sides nearly equal, the angles subcarinate; inferior extremity pointed, superior broad and convex. Test composed of many segments, the earlier ones triserial, the later uniserial. Aperture consisting of numerous minute perforations on the superior face of the terminal segment. Texture hyaline. Length, $\frac{1}{50}$ inch (0·5 mm.).

CLAVULINA, d'Orbigny.

Clavulina caperata, nov.—Test elongate, subcylindrical or fusiform, broadest below the middle; transverse section nearly circular throughout; triserial portion relatively very large. Inferior extremity tapering to a point, superior narrow, rounded, or truncate. Segments very numerous, irregular in form and arrangement, the

¹ 'Monograph of Carboniferous and Permian Foraminifera' (1876), p. 67.

² 'Mém. Acad. Sci., St. Petersburg,' ser. 7, vol. xxvii (1879), p. 39.

sutures marked by external limbate lines; chamber cavities much subdivided. Aperture central, terminal, with raised valvular lip. Length, $\frac{1}{10}$ inch (2.5 mm.).

C. indiscreta, nov.—Test elongate, three-sided, broad near the middle, and tapering towards both ends; edges rounded, except near the inferior end, where they are acute, and terminate in a point. Segments few, septation obscure externally. Texture subarenaceous, compact; surface smooth. Aperture a neat, round terminal orifice. Length, $\frac{1}{10}$ inch (1.6 mm.).

TRITAXIA, Reuss.

Tritaxia lepida, nov.—Test triquetrous, broadest near the middle, tapering towards the ends; the three sides nearly equal, the angles sharp or subcarinate. Superior end rounded and terminating in a short neck; inferior, tapering to a sharp point. Texture hyaline. Length $\frac{1}{30}$ inch (0.3 mm.).

BULIMINA, d'Orbigny.

Bulimina subteres, nov.—This name has been given to a small Bulimine form frequent in northern seas, but which hitherto has had no well-defined position. In my paper on North Polar Rhizopoda ('Ann. and Mag. Nat. Hist.,' ser. 5, vol. i, p. 436, pl. 21, fig. 12) it was provisionally assigned to *B. elegantissima*, d'Orb., with the remark that the specimens were "not of the precise contour by which the species was usually recognised;" and that though "the segments were similarly arranged, they were relatively shorter, and there were fewer in each convolution." It might have been added that the aperture is usually inserted further from the apex of the shell. In point of fact the species is almost equally related to *B. elegantissima*, d'Orb., and *B. (Robertina) arctica*, d'Orb., but it has larger, broader segments than either, and is altogether less elegantly made. Specimens from the North Atlantic are commonly from $\frac{1}{60}$ to $\frac{1}{40}$ inch (0.4 mm. to 0.6 mm.) in length, broad and rounded at the superior end, and tapering to a point; the sides are convex and but slightly excavated at the sutural lines.

Messrs. Parker and Jones ('Phil. Trans.,' vol. clv, p. 375) show that the two d'Orbignian forms above mentioned are in near relationship, but I cannot follow them so far as to include both under the same name; indeed, I should prefer to assign some of the

specimens they figure (*op. cit.* pl. 15, figs. 13—17) to the species now described rather than to *B. elegantissima*.

B. subcylindrica, nov., is another form belonging to the same group as *B. subteres*. The test is elongate, subcylindrical (not tapering), the two ends equally rounded, and the surface but little excavated at the sutures. The segments are few, and their spiral arrangement is very obscure: the aperture takes the form of a narrow, nearly erect slit, near the base of the final segment. Length, $\frac{1}{50}$ inch (0.5 mm.).

B. Williamsoniana, nov.—Test elongate, cylindrical, more or less sinuate in contour, circular in transverse section; composed of a spiral band of long narrow, nearly erect segments. Inferior extremity slightly tapering and rounded, superior obliquely truncate. Surface traversed from end to end by a series of somewhat sinuate and diagonal parallel costæ, which entirely obscure the internal structure. Aperture simple, situate in a depression at the centre of the oblique superior face, bordered by radiating lines. Length, $\frac{1}{40}$ inch (0.64 mm.) or less.

BOLIVINA, d'Orbigny.

Excepting the genus *Lagena*, there is no group of hyaline Foraminifera the knowledge of the varietal modifications of which has received larger accessions from the study of the "Challenger" material, than that comprising the aberrant forms of *Bulimina*, included under the subgeneric terms *Virgulina* and *Bolivina*. Both diverge from the typical plan of structure in their tendency to become more or less regularly biserial, instead of spiral, in the arrangement of their chambers, whilst they usually retain the characteristic Bulimine aperture. It is impossible to separate these two subgenera one from another by any well-defined or permanent peculiarity; all that can be said to distinguish them is that *Virgulina* is more Bulimine and less Textularian in the disposition of its segments, and that *Bolivina* is more Textularian and less Bulimine. Whilst, therefore, it is comparatively easy to associate *Virgulina* with its type, *Bolivina* often only betrays its affinity by the aperture, which is either comma-shaped, twisted, toothed, unsymmetrically oval, or of some other form within the range of variation to be found in *Bulimina* itself. In the varieties of *Virgulina* we find all the links connecting *Bolivina* with the typical *Bulimina*. Two or three undescribed species of *Virgulina* may be omitted from the present notice, as descriptions in few words would be scarcely intelligible with-

out figures; of *Bolivina* the following new forms may be placed on record.

Bolivina porrecta, nov.—Test elongate, straight, slightly tapering, finger-shaped, somewhat compressed; margin and ends rounded. Segments about as broad as long, the earlier ones arranged on the normal Textularian plan, the later ones taking a nearly triangular form, each extending the entire width of the test, the sutures forming a zigzag line from side to side. Walls thin and clear, very finely perforated; sutural depressions very slight. Aperture large, terminal, oblique. Length, $\frac{1}{26}$ inch (0.9 mm.).

B. limbata, nov.—Test elongate, tapering, compressed, more or less twisted; margin angular or only slightly rounded, sinuate. Sutures irregularly curved, limbate, especially near the points of contact of the two series of segments on both faces of the shell. Length, $\frac{1}{35}$ inch, (0.75 mm.).

B. tenuis, nov.—Test thin, outspread, broadly elliptical, slightly convex on both sides; margin acute. Segments few, each with a sort of supplementary lobe, the lobes collectively presenting the appearance of a series of chamberlets down the median line. Aperture on the oblique face of the terminal chamber surrounded by radiating lines. Dimensions, $\frac{1}{80}$ by $\frac{1}{100}$ inch (0.3 by 0.26 mm.).

B. laevigata, nov.—Test elongate, thin, complanate, broadest at the centre, tapering and rounded towards the ends. Segments few in number, Textularian in arrangement, broad, flattened on both faces, bordered both at sutures and periphery by a narrow band of clear shell-substance. Sutures flush; aperture large, irregularly oval, oblique. Length, $\frac{1}{60}$ inch (0.43 mm.).

B. tortuosa, nov.—Test elongate, tapering, broadest near the top; the sides bent obliquely towards the median line, so as to give the whole shell a twisted contour; margin thin, sharp, lobulate. Segments numerous, long, narrow, projecting and rounded at the free ends. Shell conspicuously perforated. Length, $\frac{1}{55}$ inch (0.45 mm.).

B. pygmæa, nov.—Test short, broad, biconvex, widest near the top, and tapering to a point at the base. Segments numerous, somewhat inflated, the peripheral ends extended into sharp points directed obliquely or horizontally. Length, $\frac{1}{60}$ inch (0.25 mm.).

B. robusta, nov.—Test elongate, compressed, broad and rounded at the superior extremity, tapering to a point,

and frequently terminating in a long, stout spine at the inferior end. Test thickest on the median line, and sloping away symmetrically to the sides; margin subacute. Segments numerous, about ten in each series; long, curved, obliquely set. Shell stoutly built, sutures thickened, usually limbate and somewhat crenulate externally. Length, $\frac{1}{45}$ inch (0.6 mm.).

B. decussata, nov.—Test elongate, compressed; broad and obliquely truncate at the superior extremity, and tapering to a rounded point at the inferior; margin thick, square, or slightly rounded, lobulate. Surface beset with low prominences or bosses, rounded or subangular in outline, arranged with some regularity in oblique rows, about four in each row, and entirely concealing the septation. Length, $\frac{1}{50}$ inch (0.5 mm.).

B. Hantkeniana, nov.—Test depressed, equally convex on the two faces; varying in contour, from a relatively long form tapering to a point at the base, to broadly oval one with rounded ends. Composed of numerous, rounded, inflated segments, in two more or less regular alternating series, surrounded by a delicate keel of varying width and completeness. Surface often traversed by short, delicate, longitudinal costæ. The long narrow specimens seldom have a continuous wing or keel, and they attain a length of about $\frac{1}{28}$ inch (0.9 mm.), whilst those of wider proportions with the broader more regular wing are less than $\frac{1}{40}$ inch long (0.6 mm.) and about $\frac{1}{50}$ inch (0.5 mm.) broad.

B. Karreriana, nov.—Test elongate, tapering, broadest near the top, somewhat depressed; inferior extremity pointed, often mucronate; margin thick and rounded, lobulate. Surface of the test ornamented with numerous delicate, often branching, or otherwise irregular, longitudinal ribs. Segments inflated; aperture large, oblique. Length, $\frac{1}{40}$ inch (0.63 mm.).

B. lobata, nov.—Test elongate, depressed, digitate; superior extremity obliquely truncate or rounded, inferior obtuse. Segments inflated, especially the later ones, their peripheral margins subangular. Surface of the later chambers more or less granulated. Sutures thickened, deeply sunk. Aperture a long oval slit contracted at the middle; nearly central. Length $\frac{1}{60}$ inch (0.4 mm.).

B. Schwageriana, nov.—Test oblong, biconvex, broadest near the middle, tapering to a blunt point at the inferior extremity; margin carinate. Keel widest near the middle of the shell, absent at the inferior end.

Sutures limbate, the limbation taking the form of raised beads or irregular lines of shell-substance on both sides of the test, chiefly near the points of contact of the two opposing series of segments. Surface otherwise smooth. Aperture large, with an oblique projecting tooth near the superior end. Length, $\frac{1}{45}$ inch (0.56 mm.); breadth near the middle of the test only slightly less.

B. amygdalæformis, nov.—Test oval, compressed, almond-shaped; ends obtuse or rounded, periphery rounded. Segments few; septation obscured by a surface ornamentation of stout, branching, longitudinal costæ. Terminal chamber nearly smooth and conspicuously perforated; aperture central, of long oval form, slightly constricted at the middle. Length, $\frac{1}{36}$ inch (0.72 mm.).

B. subangularis, nov.—Test oblong, tapering, stoutly built, more or less angular, somewhat concave or excavated on both sides; inferior extremity obtusely pointed. The angular contour is determined by the prominence of superficial costæ, the principal of which, six in number, are placed, one down each lateral margin and two down each face of the test. Aperture comma-shaped. Length, $\frac{1}{55}$ inch (0.45 mm.).

CASSIDULINA, d'Orbigny.

Cassidulina Parkeriana, nov.—Test crosier-shaped; spiral portion short, somewhat compressed, composed of few segments arranged as in *C. crassa*; linear portion straight or arcuate, cylindrical, biserial, the ends of the segments overlapping alternately; chambers short, ventricose. Aperture comma-shaped, situated on one of the lateral faces of the terminal segment, near its apex. Length, $\frac{1}{45}$ inch (0.57 mm.).

The Rev. A. M. Norman has a crosier-shaped species in some respects similar to this, with the manuscript name *Cassidulina Bradyi*, but the segments are long and oblique, and the whole shell is compressed and *Vaginulina*-like.

C. Jonesiana, nov.—Test oblong or ovate; external aspect of the superior surface like that of a very thick Rotalian, with slightly inflated chambers and rounded margin. On the inferior face the umbilical ends of the chambers fall short of the centre, leaving a deep cavity or depression, from which the aperture proceeds, taking the form of a curved, nearly erect slit, on the inferior face of the large terminal chamber. Diameter, $\frac{1}{36}$ inch (0.7 mm.).

C. subglobosa, nov.—A large, thick, few-chambered, subglo-
bular shell; the dorsal margin gibbous and rounded,
the ventral less convex; aperture in the form of an
obliquely-set loop on the ventral face of the terminal
segment. Diameter, $\frac{1}{3}$ inch (0.7 mm.).

EHRENBERGINA, Reuss.

Ehrenbergina hystrix, nov.—Shell somewhat ovate in gene-
ral form, the superior end broad and rounded. Segments
few, regular and alternate on the dorsal face, confused
on the ventral, their free ends terminating in lateral
spines. The sutural lines on the dorsal side marked
by rows of spines, sometimes fused into a fringe-like
projection from the shell-wall; the ventral surface of the
earlier segments also beset with stout spines or tuber-
cles. Aperture large, curved, situated in a depression
on the inflated face of the terminal segment, which is
ornamented externally with radiating lines. Length,
 $\frac{1}{3}$ inch (0.75 mm.).

LAGENA, Walker & Jacob.

Whilst the simplicity of the typical structure of *Lagena*
limits the range of variation in general form, it appears to
favour the production of an endless diversity of surface
ornamentation. It is impossible to recognise as "species,"
or by any word of similar significance, the successive terms
of a series where every intermediate link may easily be
found; nor is it easy under such circumstances to select the
points where the chain may best be broken to form groups
which have any approach to true specific value. In append-
ing names, therefore, to some of the more striking and more
easily defined modifications of the genus, it is to be under-
stood that they are no more than varietal or subvarietal
distinctions. Under these circumstances it has not been
thought necessary, at the moment, to do more than indicate
characteristic peculiarities, whether of contour or ornament.

Lagena botelliformis, nov.—Test unornamented; long, cylin-
drical, of even diameter, arcuate, ends rounded; entoso-
lenian.

L. quinquelatera, nov.—A five-sided modification of *L. lævis*;
angles sharp or carinate; surface unornamented or very
faintly striate; ectosolenian.

L. stelligera, nov.—Pyriform, ento- or ecto-solenian, with a
circular rim or collar at the base, one third the diameter
of the shell, and a number of short ribs (8—12) radiat-
ing from it.

- L. longispina*, nov.—A variety of *L. globosa*, either globular or somewhat compressed, armed with long, stout spines at the base.
- L. unguiculata*, nov.—Pyriform, compressed; inferior end broad and tapering to a thin edge, which is furnished with a number of curved teeth set symmetrically.
- L. samara*, nov.—Test elongate, compressed, leaf-shaped, tapering to a point at both ends; consists of a central, circular, bi-convex chamber, with a large peripheral wing, narrow at the sides, but much developed at base and apex.
- L. tubulifera*, nov.—Chamber oval or pyriform, biconvex, with long ectosolenian neck; periphery furnished with a broad laminar wing traversed by parallel or radiating tubuli.
- L. tubulifera*, var. *tenuistriata*, nov.—A subvariety of the last-named, the body of the shell ornamented with delicate longitudinal striæ.
- L. fimbriata*, nov.—Compressed, broadest at the base, tapering upwards; ento- or ecto-solenian; furnished with a deep perpendicular wing or fringe running round the oval base; the wing traversed by parallel tubuli.
- L. auriculata*, nov. (*typica*).—Pyriform, compressed bilaterally, usually entosolenian; on each side, near the base, a loop-like wing encloses a portion of the peripheral margin; or sometimes the whole periphery is bordered by a wing which divides near the base, on each side, so as to form a sort of loop. When the wing forming the loop is deep it is usually tubulated.
- L. auriculata*, var. *substriata*, nov., has, in addition, indications of riblets near the base and apex of the test.
- L. auriculata*, var. *costata*, nov., has the body of the shell strongly costate, and is frequently armed at the base with short spines.
- L. squamoso-alata*, nov.—Body of the test like *L. squamoso-marginata*, P. & J., but with a further ornamentation consisting of a reticulated border and a broad tapering wing with radiate marginal markings.
- L. variata*, nov.—Shape unsymmetrical, subglobular, gibbous, somewhat compressed, with an entosolenian aperture at each end. Surface-ornament consisting of irregular, slightly raised, rounded, longitudinal riblets.
- L. exsculpta*, nov.—Shaped like *L. globosa*, or somewhat compressed; entosolenian. Surface-ornament consisting of an excavated star radiating from the centre of the inferior end. Radii fluted, broad, and rounded at

the upper extremity, extending nearly half-way up the test.

- L. Wrightiana*, nov.—Test oval flattened, with a thin peripheral border, surmounted by a stout sessile phialine lip; aperture entosolenian. Surface-ornament consisting of a number of longitudinal, parallel, excavated grooves covering the two sides, except the central portions which are smooth.
- L. favoso-punctata*, nov.—Shape variable; surface-ornament consisting of a raised reticulation, with an orifice or perforation in the middle of each depression.
- L. Schulzeana*, nov.—Test oval, compressed, sub-carinate; sides flat; neck wide and very short, finished with a rounded lip. Surface-ornament consisting of transverse bars, horizontal in the middle and bent downwards at an angle, near the periphery.
- L. trigono-ornato*, nov.—General form similar to *L. trigono-marginata*, P. & J. The peripheral angles are limbate, reticulated externally, and much perforated.
- L. plumigera*, nov.—Flask-shaped, with long slender neck; surface-ornament consisting of ten to twelve longitudinal costæ, developed (especially at their lower ends) into wide tubulated wings.
- L. quadralata*, nov.—Flask-shaped, ectosolenian; furnished with four equi-distant, broad, tubulated wings, reaching from near the extremity of the neck to the base of the shell; the body of the test having an additional surface-ornament of fine longitudinal striæ.
- L. torquata*, nov.—Test flask-shaped with tapering neck. Surface-ornament consisting of broad longitudinal costæ with depressions or perforations at regular intervals down the centre of each; alternating with these are narrower non-perforate ribs, and the whole are united by secondary or less elevated crossbars.
- L. Hertwigiana*, nov.—Pyriform, with delicate ectosolenian neck rising abruptly from the apex. Surface finely reticulated, each angular mesh with a conspicuous perforation in the centre. Sections show that the shell-wall is double, that the intermediate space is divided into cells or chamberlets by perpendicular walls, of which the external areolation marks the position, and that the larger perforations open into the centre of the cells. Length, $\frac{1}{75}$ inch (0.34 mm.).

This is a particularly interesting species in its bearing upon recently expressed views on the *Dactyloporidæ*. Here, at least, is an undoubted hyaline Foraminifer

with a general aperture in a delicate transparent ectosolenian neck, and a cellular shell-wall like *Oculites*, each chamberlet provided with an external orifice.

NODOSARIA, Lamarck.

Nodosaria intercellularis, nov.—Test arcuate (Dentaline), inferior extremity usually mucronate, composed of about six segments, the earlier of which are sub-cylindrical, or only slightly inflated, the later ones elliptical or pyriform. Surface-ornament of the earlier segments consisting of longitudinal costæ; the later chambers marked by lines of closely set perforations which communicate with chamberlets formed in the furrows between the ribs. The structure of the later segments closely resembles that of *Lagena Hertwigiana*. Neck long, with annular or spiral raised ornament and phialine or cleft lip. Length, $\frac{1}{15}$ inch (1.6 mm.).

N. abyssorum, nov.—Test stout, thick-shelled, nearly straight, often irregularly built. Segments about five in number, subglobose, somewhat irregular in shape and size; primordial chamber, which is usually the largest, furnished at its base with a number of short stout spines; neck short and broad, with large phialine lip. Length, $\frac{1}{9}$ inch (2.8 mm.).

VAGINULINA, d'Orbigny.

Vaginulina spinigera, nov.—General form that of short, broad, somewhat tapering specimens of *V. legumen*, but furnished at the base with two (rarely three or more) long stout spines, one of which is usually continuous with the main axis of the shell, the others radiating at various angles. Length of the body of the shell, $\frac{1}{7}$ inch (3.5 mm.), the spines often two thirds as much, or even occasionally as long as the shell itself.

Mr. Whiteaves has accurately described this form,¹ but beyond alluding to it as a species of *Marginulina*, has not given it a name. In one of the dredging lists published by the late Dr. M. Sars, the name *Marginulina spinosa* occurs,² but without any description or other indication of characters, and it is difficult now to say what was intended. So far as the distinction between *Vaginulina* and *Marginulina* is of any value, the species appears to belong to the former rather than the latter genus; and as the want of a recognised name for it has been a source of some inconvenience,

¹ 'Report Brit. Assoc.,' 1872; 'Trans. Sections,' p. 144.

² 'Vidensk.-Selsk. Forhandlinger' for 1868, p. 248.

it seems best to take this opportunity to supply the deficiency.

CRISTELLARIA, Lamarck.

Cristellaria Siddalliana, nov.—Test spiral, explanate, with a tendency to become centrifugal or crosier-shaped; extremely thin, usually surrounded by a broad, delicate wing, except the septal or ventral face of the terminal segment; the wing often extending between and separating the last two convolutions of the discoidal portion. Segments numerous, very slightly inflated, forming two or more convolutions, the whole of which are visible on both sides of the shell. Longer diameter, $\frac{1}{20}$ inch (1.26 mm.) or more.

C. gemmata, nov.—Test broad, oblong, compressed (Planularian); earlier chambers spiral and embracing, later ones broad and arcuate; each segment ornamented with a row of exogenous heads either upon the sutural lines or parallel to them. Length, $\frac{1}{20}$ inch (1.26 mm.).

POLYMORPHINA, d'Orbigny.

Polymorphina longicollis, nov.—Test long-ovate, subcylindrical or fusiform; segments few, erect, slightly ventricose, the final one hispid externally, and terminating in a long neck with phialine lip. Length, $\frac{1}{40}$ inch (0.6 mm.).

An interesting intermediate link; the general characters are those of *Polymorphina*, the neck and lip essentially those of *Uvigerina*.

UVIGERINA, d'Orbigny.

Uvigerina spinipes, nov.—Test elongate, subcylindrical, slightly compressed on three sides; tapering to a point at the inferior end, and armed with numerous spines directed downwards. Segments inflated, distinct, somewhat irregularly combined. Length, $\frac{1}{33}$ inch (.77 mm.).

SAGRINA, d'Orbigny.

Sagrina columellaris, nov.—Test long, nearly straight, cylindrical, slightly tapering; inferior extremity round or bluntly angular; superior, broad and convex. Uvigerine chambers few, distinct; uniserial segments numerous, short, very little constricted at the sutural lines. Aperture large, simple, with sessile phialine lip. Length, $\frac{1}{23}$ inch (1.1 mm.).

S. bifrons, nov.—Test elongate, compressed, both sides slightly concave along the median line; margin thick

and rounded. Uvigerine chambers few, distinct; those of the linear series numerous, short, not inflated. Sutures flush externally; septa thickened by deposit of clear shell substance. Aperture large, oval, surrounded by a sessile lip. Length $\frac{1}{30}$ inch (0·84 mm.).

DISCORBINA, Parker & Jones.

Discorbina tabernacularis, nov.—Test conical or tent-shaped, sides somewhat arched, inferior surface concave. Segments long, oblique, arranged in about three convolutions; septal lines externally limbate in small specimens, in larger ones hidden by the general thickening of the shell-wall. Inferior surface ornamented with radiating striæ or crenulations; superior with striæ or irregular costæ radiating from the apex. Diameter, $\frac{1}{100}$ inch (0·25 mm.).

In some localities specimens of *D. tabernacularis* are met with in pairs, that is to say, two shells firmly attached by their bases. The same condition is not unfrequent in *Discorbina pileolus*, d'Orb., and *D. Parisiensis*, d'Orb.

TRUNCATULINA d'Orbigny.

Truncatulina rostrata, nov.—Test biconvex, subnautiloid, slightly unsymmetrical; periphery thin, subcarinate. Chambers equitant; about ten in the final convolution, which completely encloses the penultimate. Sutures limbate, especially near the centre; marked by indentations at the periphery. The true aperture is an arched, labiate opening, placed transversely on the face of the terminal segment, close to the margin of the previous convolution; but there is usually, in addition, a second or spurious orifice, in the form of a vertical slit in the beak-like projection of the peripheral angle of the same. Diameter, $\frac{1}{30}$ inch (0·84 mm.).

Tr. Robertsoniana, nov.—Shell spiral, lenticular; superior surface slightly convex; inferior convex, somewhat depressed at the umbilicus; consists of four or more convolutions, of which the whole are visible on the superior face, whilst on the inferior the last whorl conceals all preceding it, except a small area in the centre. Segments very numerous, 13 or 14 in the final convolution. Periphery angular, even, not constricted at the sutures. Colour, rich brown, deepest near the centre and at the sutural lines. Diameter, $\frac{1}{33}$ inch (0·7 mm.).

Tr. margaritifera, nov.—Shell spiral; slightly convex or nearly flat on its superior surface, convex on the inferior; margin sharp, subcarinate, lobulate. Chambers very numerous, all visible on the superior face, the last convolution only on the inferior. Sutural lines on both sides marked by rows of exogenous beads of clear shell-substance, largest near the centre of the test. Diameter, $\frac{1}{20}$ inch (1.26 mm.).

Tr. soluta, nov.—Shell elongate, compressed; composed of a line of inequilateral segments, arranged spirally, the earlier ones embracing, the later ones free. Periphery sharp, furnished with a tubulated fringe or keel, and the surface of the shell otherwise more or less ornamented with tubercles. Aperture a curved slit in the line of the periphery at the extremity of the last chamber, furnished with a phialine lip. Length, $\frac{1}{70}$ inch (0.36 mm.).

PULVINULINA, Parker & Jones.

P. procera, nov.—Shell spiral; superior surface forming an elevated cone with rounded apex; inferior, flat or truncate. Chambers numerous, about six in the last convolution, oblique; segmentation usually obscure, except on the inferior aspect, where the sutures and periphery are more or less limbate. Aperture, an arched slit on the inferior side of the last segment, near the umbilicus. Diameter, $\frac{1}{22}$ inch (1.1 mm.).

POLYSTOMELLA, Lamarck.

Polystomella imperatrix, nov.—Test spiral, symmetrically discoidal, complanate; peripheral margin rounded or subangular, furnished with several (three to six) stout spines. Septal ridges only slightly limbate, marked with pitted depressions; retral bars very numerous, delicate, irregular, sometimes branching. Diameter, $\frac{1}{15}$ inch (1.7 mm.).

P. verriculata, nov.—Test spiral, much depressed; sides flattened; margin angular or slightly rounded. Septal ridges and retral bars forming a coarse, more or less regular, raised network, covering the surface of the shell. Diameter, $\frac{1}{50}$ inch (0.5 mm.).

CYCLOCLYPEUS, Carpenter.

Cycloclypeus Guembeliana, nov.—A single specimen, nearly complete, of a discoidal foraminifer referable to Carpenter's genus *Cycloclypeus*, and a fragment of a second

of the same species, were found in material dredged in 210 fathoms off Kandavu, one of the Fiji Islands. Their structure is of much simpler type than that of the gigantic discs dredged by Sir E. Belcher on the coast of Borneo, which formed the basis of Dr. Carpenter's description of the genus. The better specimen is a thin disc about $\frac{1}{16}$ inch (1.5 mm.) in diameter, somewhat biconvex; the convexity is chiefly in a limited area near the centre of the test, the remainder being thin, and tapering to a sharp edge at the periphery. The texture is distinctly hyaline.

This little shell appears to represent the "central chambered plane" of the large forms, without the thickened shelly plates on the upper and lower surface. The chambers form a single layer, disposed in tolerably regular annuli; in shape they are nearly square, not elongate in the direction of the radii as in the larger species, and the septal lines are slightly raised externally.

I would suggest, for the sake of distinction, that the large type, which, I believe, has never received a specific name, should be called *Cycloclypeus Carpenteri*; that now described I propose to name after Professor Gumbel, of Munich, who has worked with so much success on the allied genus *Orbitoides*.

3. Note on "*Biloculina-mud*."

In the second paper of this series,¹ some remarks were offered upon the Foraminifera collected at or near the surface of the ocean by means of the tow-net. A list was given of the free-swimming species, so far as they were known, and the question whether all the varieties of *Globigerina* and the three or four pelagic species of *Pulvinulina*, live exclusively at the surface of the open sea, was discussed. The recorded facts bearing upon the subject were summarised, as well as the results of my own observations, not with the view of announcing any conclusions in the matter, but chiefly in the hope of eliciting further contributions to the knowledge of a subject, concerning which there was still much to be learnt. The question, from a zoological stand-point, is now a comparatively narrow one. It is not whether Foraminifera do live at the bottom of the sea,

¹ 'Quart. Journ. Mic. Sci.,' vol. xix, N.S., p. 78, "Notes on Pelagic Foraminifera."

down to its greatest depths, for of that there can be no reasonable doubt; it does not even affect the greater number of types which are found in *Globigerina*-ooze, for of the forty or fifty species or more which *Globigerina*-mud often contains, those to which it refers may not exceed half a dozen, the remainder being recognised on all hands as living their whole life at the bottom. The point still in debate is, as already indicated, whether a certain limited number of forms live *only* at the surface, or also at various depths down to the floor of the ocean; and it derives its chief interest and importance from the fact that individuals of these few species occur in such enormous numbers that in many areas they constitute the mass of the calcareous deposit. The cruise of the "Knight Errant" during the past summer has in part removed one of the minor difficulties which were put forward as negative evidence, by furnishing us with surface gatherings of small non-spinous *Globigerinæ* from an area in which they had not previously been collected, and this is satisfactory as far as it goes: on the other hand, the comparison of the surface and bottom specimens, though not yet completed, appears to supply an argument in the opposite direction. I do not propose at the present moment to enter again upon the discussion of this subject, though I hope to revert to it at a future time; my object is rather to offer a few notes upon the fauna of the sea-bottom over an area in which the porcellanous Foraminifera (*Miliolidæ*), which are known to be exclusively bottom-living species, not only furnish the most characteristic feature of the deposit, but form by far the most important and bulky constituent.

Professor G. O. Sars, of Christiania, in his official report on the Norwegian Sea-fisheries for the year 1876,¹ gives a short account of the biological conditions of the northern "deep-water cold area," which occupies a considerable portion of the region between Norway, Bear Island, and Spitzbergen on one side, and the Farøe Islands, Iceland, and Greenland on the other. This region has a bottom temperature of from 0° to 1.6° Cent. (32° to 34.9° Fahr.), and the depth ranges from 300 to 2000 fathoms. The sea-bed, especially of the deeper portions of the area, consists of a soft, light-coloured, sticky mud, of nearly uniform composition; that is to say, composed in very large proportion of one species of porcellanous Foraminifera, *Biloculina rin-*

¹ "Indberetninger til Departementet for det Indre fra Professor, Dr. G. O. Sars om de af ham i Aarene, 1864--1878, aanstillede Undersogelser angaaende Saltvandsfiskerierne." Christiania, 1879.

gens. Professor Sars has been kind enough to send me a characteristic sample of this "*Biloculina*-mud," with the following particulars as to locality :

"Station 52—Lat. 65° 47·5' N., Long. 3° 7' W.; depth 1862 fathoms ; temperature at the bottom 1·2° Cent." (about 34° Fahr.).

The fine impalpable silt had been partly removed before I received it, I therefore completed the cleaning by washing it thoroughly on a sieve of 120 meshes per linear inch, through which no particles larger than 0·005 of an inch in diameter could pass. The loss was about 6 per cent. of the entire weight, and, of the impalpable material thus separated, about one half was calcareous, the particles evidently consisting of the *débris* of foraminiferous shells, and the other half fine silicious sand. I have no information as to the proportion of impalpable mud in the dredged material before the preliminary washing, but as it is said to be sufficient to incorporate the whole into a sticky paste, which on being dried forms a hard, light-coloured, calcareous mass, it must be considerable. The composition of the material as I received it from Professor Sars was as follows—the proportions stated are by weight :

<i>Biloculina ringens</i> (one half being entire shells)	. . . . .	50 p. c.
<i>Haplophragmium subglobosum</i>	. . . . .	20 "
<i>Globigerinæ</i> (the minute arctic form)	. . . . .	4 "
Sand and small fragments of rock with a few Forami-		
nifera other than the above-named	. . . . .	20 "
Impalpable <i>débris</i>	. . . . .	6 "
		100

Assuming that the calcareous part of the impalpable mud consists of the disintegrated shells of the same species in similar proportions, the total amount of the deposit derived from surface organisms would not in this case exceed 4 per cent. even were *Globigerinæ* at all times pelagic.

The specimens of *Biloculina* are very uniform ; they are of the stout, inflated, typical form, with a small admixture of the depressed carinate variety, *B. depressa*, d'Orb. Hardly less remarkable is the existence of so large a proportion of one of the comparatively small, nautiloid, arenaceous species, *Haplophragmium subglobosum* ; and here again the specimens show scarcely any variation in minor characters. The *Globigerinæ* are all of the minute, subglobular, thick-shelled, arctic type, which may be fitly named *Gl. Dutertrei*, var. *borealis*. Altogether sixteen species of Foraminifera were noted; but beyond those already alluded

to they were unimportant and represented by few individuals.

A sufficient number of apparently clean specimens of *Biloculina* were selected for chemical analysis, but the result gave a proportion of silica which suggested that notwithstanding the careful washing to which they had been subjected, the chamber cavities had retained a certain amount of sand. The experiment, however, was sufficient to prove that the tests contained no earthy carbonates except carbonate of lime, and no phosphates.

The analysis of *Haplophragmium subglobosum* was more satisfactory, and as it is interesting to compare the chemical composition of the test of one of the non-labyrinthic *Lituolæ* with that of a labyrinthic type such as *Cyclammia cancellata*, of which the analysis was given in a previous paper ('Quart. Journ. Mic. Sci.,' vol. xix, N.S., p. 25), I append the details. As often heretofore I am indebted to my friend, Mr. J. T. Dunn, B.Sc., for practical help in the chemical portion of the subject.

Haplophragmium subglobosum.

Silica	76.10
Peroxide of iron with some alumina	16.30
Carbonate of lime	7.30
	99.70

The alumina was not separately determined, but as it only exists in small proportion, the importance of peroxide of iron as a constituent is evident; and that the percentage is even larger than in *Cyclammia* is a noteworthy fact. No phosphoric acid was present nor was there any trace of magnesia.

In a recent letter, referring chiefly to the *Biloculina* deposit, Professor G. O. Sars states that in the portion of the Arctic Ocean lying east of the cold area already alluded to, namely, east of Finmark, Bear Island, and Spitzbergen, an entirely different bottom-fauna prevails. In this eastern area the characteristic rhizopod is the large, stellate, arenaceous type *Rhabdammina*, which exists in such abundance as to render the term "*Rhabdammina-ooze*" not inappropriate for the dredged mud.

I can scarcely conclude these preliminary papers without expressing the obligation I am under to some of my old fellow-labourers in the same field of research. But for their

encouragement and ever ready help, the tedious details of mechanical work which have occupied so much of my time during the last four years or more, would have been wearisome in the extreme. I hope in the proper place to make due acknowledgment of many acts of courtesy that I cannot enumerate here, and I will now do no more than mention the names of Rev. A. M. Norman, Professor T. Rupert Jones, Dr. Carpenter, and Professor W. K. Parker, as amongst those to whom I am primarily indebted for assistance and advice.

POSTSCRIPT.

Since the foregoing paper has been in print, I have received through the kindness of Herr Gustav Steinmann, a copy of his recently published memoir, "Die Foraminiferengattung *Nummoloculina*, n.g." Without entering into any discussion of the views therein expressed, I may just state that the *Nummoloculina contraria* of Herr Steinmann is in part, at least, the *Hauerina borealis* of the present paper (p. 46). The difficulty of distinguishing *Hauerina borealis* and *Biloculina contraria* has been already alluded to, and if the views put forward by Herr Steinmann be correct, is now satisfactorily disposed of. At the same it must be remembered, on the one hand, that between *Biloculina sphaera*, d'Orb. and *B. contraria*, d'Orb. every gradation of form is to be found in northern dredgings; and on the other, that the alar prolongation of the chamber-walls is a character shared by other species of *Hauerina*.

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