more numerous, and that by far the greatest number have been young and immature specimens. I have counted as many as thirty in one *Medusa*, and only a few of these were adults. In other instances, however, and that too of the most common occurrence, the numbers would vary from one up to about a dozen. But it must not be taken for granted from this that every *Medusa* has its *Hyperia*. This is by no means the case. I have seen multitudes without any.

As for *Lestrigonus Kinahani*, the forms so named are ever the fewest thus met with cooped up, and all have seemingly arrived at a state of maturity. I have never yet seen a young or small example of this species in a *Medusa*, but have taken them free. There appears to be little or no difference between the young and the old. They are both slender, and of a dark lead-colour, and both have the remarkable long and hair-like antennæ.

But besides these I have likewise taken *Anonyx Edwardsii*, *Dexamine spinosa*, *Atylus Swammerdamii*, *A. bispinosus*, *Eurydice pulchra*, and once a small specimen of *Portunus marmoreus* from *Medusæ*; yet who would ever think of calling these creatures parasitical? Carcinologists do not, neither will we—although some of them may have occasionally been seen taking a quiet ride on the back of some of the smaller *Medusæ*.

It will be seen from the foregoing that only two species, viz. *L. Kinahani* and *H. galba* (m. & f.), have been in a measure particularly alluded to. The others will form the subject of and be more fully treated in another Note.

On the Surface-fauna of mid-Ocean. By Major Samuel R. I. Owen, F.L.S., F.A.S.L., F.M.S.L., Associate of King's College, London.

[Read June 7, 1866.]

[Plate V.]

No. 2.—Foraminifera.

In a paper read before the Society and published in vol. viii. of the 'Journal,' (page 202) I mentioned that I had found some genera of the Foraminifera living on the surface of the ocean. I wish in my present communication to give the names of the species and the localities in which I have met with these Rhizopods, together with such other observations on them as may appear worth

recording. Like their kindred the Polycystina, they appear on the surface after sunset. All that I have hitherto met with have been, as might be expected, of the unattached forms, and they are all included in the two genera *Globigerina* and *Pulvinulina*.

To *Orbulina*, which likewise is constantly met with on the surface, I shall refer presently.

All the varieties of form of *Globigerina*, in Mr. Parker's opinion, may be included in two or three subspecies; *G. bulloides*, *G. inflata*, and *G. hirsuta*.

Of the genus *Pulvinulina*, *P. Menardii* is the principal representative. *P. Micheliniana* is met with somewhat more rarely. *P. canariensis*, which the same authority considers to be but a starved-out form of *P. Micheliniana*, is also found. *P. crassa*, an Old Chalk form, I have met with in the South Atlantic. These two genera both belong to the second family, Globigerinidæ, of Dr. Carpenter's suborder Perforata.

I have never met with any trace, not so much as a single individual, of the Imperforata, or of the families Lagenidæ and Nummulinidæ of the Perforata. Thus we find one genus of the subfamily Rotalinæ, and one genus of the subfamily of the Globigerinæ, alone making the surface of the ocean their home.

I have never met with any form of the subfamily Textularinæ.

With regard to *Orbulina*, Dr. Carpenter in his work 'An Introduction to the Foraminifera,' at p. 177, states that it has been considered to be but a development of *Globigerina*, and that the young of that genus have been found within it; in fact it is but a form of *Globigerina*. I think he is quite correct, with the exception that it does not contain the young of that genus: a few small chambers attached to each other, precisely as in the commonest form of *G. bulloides*, which are generally of a size inconsiderable compared with the outer sphere, are all that are found inside it; they are firmly attached to its inner surface, and I consider them to be its own proper chambers.

Orbulina may have no internal chambers; sometimes it has two or three, at other times many may be found within.

I have not met with any *Orbulinæ* that have a large aperture externally; but their whole surface is perforated with smaller and larger openings for the passage of the sarcode. Dr. Wallich in his 'North Atlantic sea-bed,' mentions his having found an Annelid at the bottom of the deep sea, to which he gives the credit of boring the shells of the *Globigerinæ*. I fancy it quite likely that the holes found in the *Orbulina* may be due to the same cause.

The outer sphere may be regarded as a wild-growing closing-in chamber; this form of growth is at times imitated by *Pulvinulina*, the outer chambers of which species then take on the same texture as is common to the outer chambers of *Globigerina* (*Orbulina*) *universa*. I am indebted to Mr. Parker for showing me precisely analogous cases in the growth of *Cymbalopora* and *Discorbina*; but in each of these genera it appears to be much rarer than in *Globigerina*.

I propose to make *Orbulina* a subgenus of *Globigerina*. The internal chambers are in form remarkably like those of *Globigerina*, and like them, also, they present themselves with varying surfaces, some free from, while others are covered with, spines. The form without internal chambers has been known under the name of *Orbulina universa*; I propose now to call it *Globigerina* (*Orbulina*) *universa*. The two forms containing the internal chambers may be regarded as subspecies, and appropriately designated *Globigerina* (*Orbulina*) *continens*, n. sp., and *Globigerina* (*Orbulina*) *acerosa*, n. sp., respectively,—the former being without, and the latter having, spines on some of its internal chambers. These spines, as well as those of *G. hirsuta*, are composed principally of carbonate of lime. I have found that they dissolve in weak acid; and under Mr. Parker's treatment with boiling potassa they were unaffected, which proves them to be not siliceous.

These spines on *G. hirsuta* have been looked upon as ossifications of the pseudopodia; but I find on examination that they do not take their rise from the centre of the honeycombed depressions of the surface in which the apertures are situated to admit of the extrusion of the sarcode, but are continuations of the material of the raised portions of the shell which surround the hollows. From their delicate nature, most of them get broken off in the nets; when unbroken, their ends are pointed, not very finely, but somewhat resembling the ends of *Belemnites mucronatus*. The texture and formation of these outer chambers in *Globigerina* (*Orbulina*) *universa* vary considerably—from a thin, fragile ball, to one in every respect equalling in thickness the chambers of *G. bulloides*.

The habits of *Globigerina* and *Pulvinulina*, I have proved to be identical, inasmuch as both frequent the surface of the ocean, to the possible exclusion of all other forms of the Foraminifera, and have the power of rising to and descending from the surface.

The one I find placed by Dr. Carpenter at the highest, and the other at the lowest, end of their respective subfamilies. I think

it desirable that they should be brought together and made into a separate and what appears to me to be a natural family, for which I propose the name of Colymbitæ*.

This family, then, will include two genera that, perhaps, ought never to have been separated, as their affinities are strongly marked, and their habits, and probably their structure, differ from those in the other forms of the Foraminifera.

Their having the power of rising to the surface surely shows that the animal must have some special means or organs adapted to this purpose; although they may not be distinguishable at present to our observation, the fact, I think, may be taken for granted. This family of the Foraminifera may then be considered to be the most nearly allied to the Polycystina, which, as I have before proved, are frequenters of the surface of mid-ocean.

Observation may yet show us the means used by both to enable them to rise and sink at pleasure. I may here mention that the *Acanthometræ* appear to have the same power and habits; and we may therefore infer that all these Rhizopods have some portion of their organization in common: I am not yet prepared to say whether or not all the recent known Polycystina may be found on the surface.

Dr. Wallich, in his work on the 'North Atlantic sea-bed,' does not appear to be able to prove quite satisfactorily that the *Globigerinæ* which he succeeded in getting from the bed of deep portions of the ocean were absolutely alive at the time taken; for he has the following passage at page 136:—"Under the most favourable circumstances and only after the lapse of considerable time do the shallow-water forms, when in captivity, exhibit pseudocyclosis or extend their pseudopodia; and hence, since it is in the last degree unlikely that those brought up from extreme depths should present these evidences of vitality, we must rest content with collateral proofs: fortunately these are of a very satisfactory kind." From this it will appear that the rising of these shells from the bottom after they have once fallen to it, is not yet satisfactorily proved.

That Dr. Wallich does not consider the *Globigerinæ* to be distributed through the waters of mid-ocean the following quotation from his work will show; and from it will be seen likewise that their shells are found as universally distributed at the bottom as I have proved them to be on the surface. "The minute calcareous shells of the Foraminifera are the most frequent and widely dis-

* From κολυμβητὴς, a diver.

tributed organizations of the ocean. They occur in all seas, in more or less abundance. But there is one genus (namely *Globigerina*) which may be regarded as essentially oceanic, since it is to be found in all latitudes, and at all depths, ranging from 50 to 3000 fathoms. Its seat of maximum development is on the deepest areas of the sea-bed. There, like the sands of the shore, it strews hundreds of square miles of surface, and apparently builds up vast strata. The great superficial current of the Atlantic does not bear it away in countless multitudes from tropical coast-lines, nor does the body of the ocean itself constitute its habitation."

To this there is the following note affixed at page 137:—"By sinking very fine gauze nets to considerable depths, I have repeatedly satisfied myself that *Globigerina* does not occur in the superficial strata of the ocean. On one occasion a small bag was drawn up through 700 fathoms of water in a locality where *Globigerina* abounded on the sea-bed, without entrapping a single shell."

To those whose minds are so constituted as to admit the conception of unlimited time for submarine deposits, the insignificance in size and quantity of this the Colymbitic family of the Foraminifera will be no obstacle to believing that the surface is their home; others, who wish for a larger and quicker supply to account for such deposits, must still look, with Dr. Wallich, for the abundance necessary to suit their views, to what may prove to be but their sepulchre.

I do not think with Dr. Wallich that it is absolutely necessary for these forms to sink to or to reside at any great depth for the purpose of recruiting their store of carbonate of lime, which is there supposed to be held in solution in greater quantities than at the surface, where, in mid-ocean, it is either altogether absent or very nearly so; while, on the same authority of Bischoff as quoted by Dr. Wallich at page 122, there are more than $3\frac{1}{2}$ of chloride of calcium in every 100 parts of soluble material contained in the salt water of the ocean, which in itself contains $3\frac{1}{2}$ per cent. of such soluble matter; and the supply of carbonic acid can be drawn from the atmosphere, either directly, or after its having been dissolved by the surface-water which they frequent. Such a little bit of chemistry, I take it, can be easily performed by organized beings.

At page 155 of the same work we find the following:—"The conditions prevailing at great depths render it impossible for

organisms still constituted to live under them to rise to the surface, or for the remains of these organisms after death to make their appearance in shallow water." If this important proposition at which Dr. Wallich arrived has been really established, then the rising of the *Globigerinæ* to the surface after having once subsided to the bottom, or to any considerable depth, is an impossibility. But on the other hand he says, in the same paragraph, "The conditions prevailing on the surface of the ocean render it possible for organisms to subside after death to the greatest depths, provided every portion of their structure is freely pervious to fluid." Now, as the Foraminifera are found living on the surface, if such laws prevail, they could never have been generated at, nor risen from, the bottom, but they might have been generated at or near the surface, and those found below might have subsided before or after death: we can hardly suppose that the two localities could produce precisely the same living organisms, if all communication from below upwards, in consequence of the existence of such a law, had been cut off between them. I therefore think it most probable that the Foraminifera found at the bottom were dead, or that they must have some means of again rising to the surface. To those who consider this impossible it must be left to get over the difficult ground interposed in the form of two or three miles of water, if they still consider that the bottom of the ocean is their natural habitat and the place at which they are bred.

I will now proceed to give the results furnished by my nets in the different localities over which I have worked.

The remarks made on each spot (for which the latitude and longitude are given) may be generally considered applicable to the whole space between it and the preceding one; for each portion was carefully gone over, day and night, in calm and storm, nets suited to the weather and rate of sailing having been used.

My observations in the Bay of Bengal must be taken as very incomplete. I was not on any occasion devoting my researches especially to the Foraminifera, but to other forms of life; and the state of my health on the last occasion when leaving India interfered with my work during the first part of the voyage.

The rest may be depended upon, with the exception of a few degrees near the Cape of Good Hope. After leaving lat. 37° S., and long. 26° E., I had no nets out for some three or four days.

At the head of the Bay of Bengal during the months of November and December, February and March, I found a few spe-

cimens of *Globigerina bulloides* of both forms, No. 1 and No. 2 as here represented (Plate V. figs. 6 & 7), also a very few of *Pulvinulina Menardii*. Running down the bay in long. 90° as far as 15° south, these forms continued to be met with, but in no great abundance.

In lat. 17° S., long. 80° E., I met with a very few of *G. bulloides* No. 2, and *G. inflata*.

From this point to lat. 22° S., long. 72° E., although the surface of the ocean was not altogether free from Foraminifera, *G. bulloides* No. 2 was but rarely found.

In 26° S. lat., and 55° E. long., the Foraminifera for the first time became at all plentiful. *G. bulloides* No. 2 was here very fine in size, and the most common form; *G. inflata* was here very large, but few in number; *G. bulloides* No. 3 and *G.* (*Orbulina*) *universa* were likewise present, and the individuals large.

About 250 miles south of Madagascar, in lat. 29° S., long. 46° E., *G. bulloides* No. 1 and *G. inflata* were still fine and plentiful.

In lat. 26° S., long. 51° E., the centre of this track, where Foraminifera abounded, not a trace of them could be found during the daytime.

At about lat. 29° S., long. 43° E., Foraminifera were very scarce.

In lat. 31° S., long. 31° E., very near the south-east coast of Africa, there were a very few of *G. bulloides* No. 2, and I met with but one specimen of *G. bulloides* No. 1.

Running along the coast to lat. 32° S., long. 30° E., none were taken in the nets.

In lat. 33° S., long. 29° E., a very few of *G. bulloides* No. 2 made their appearance, with one specimen of *G. bulloides* No. 1.

In lat. 37° S., long. 26° E., the Foraminifera were a little more plentiful, but still very few, and the individuals small: there were some of *G. bulloides* No. 1 and *G. bulloides* No. 2, and *G. inflata* was not entirely absent.

After passing the Cape of Good Hope, and before reaching lat. 33° S., long. 12° E., I found a great change; the Foraminifera had become very abundant, very much more so, even, than they had been to the south-east of Madagascar. *G. bulloides* Nos. 1 and 2 and *G. inflata* were equally common; but *Pulvinulina Micheliniana* here made its appearance, a very few small specimens of *Pulvinulina Menardii* were also present, and *Pulvinulina canariensis* likewise showed itself.

From this point to lat. 30° S., long. 9° E., the Foraminifera became still more abundant, and continued so to lat. 21°, long. 0°.

G. bulloides Nos. 2 and 3, *G.* (*Orbulina*) *universa*, and *G. inflata* were in abundance, with one or two specimens of *P. Menardii*. *P. canariensis* was moderately plentiful, *P. crassa* was present, and I here observed some three or four individuals of *G.* (*Orbulina*) *universa*.

In lat. 28° S., long. 7° E., the number of Foraminifera found on the surface had arrived at its maximum. *G. inflata* was the principal form; *G. bulloides* Nos. 1 and 2, *P. canariensis*, and *P. Micheliniana* plentiful; a few of *G.* (*Orbulina*) *universa*, and one or two of *P. Menardii* were also found.

In lat. 27° S., long. 5° E., *G.* (*Orbulina*) *universa* became more common, and many of them were less round in their form. *G. bulloides* No. 2 and *G. inflata* plentiful, but *G. bulloides* No. 1 not quite so abundant as before; a trace of *P. Micheliniana* still met with.

In lat. 25° S., long. 3° E., the net was towing from four in the afternoon till daylight next morning, and showed that but very few Foraminifera were on the surface; there were more of *G. bulloides* No. 2 than other forms; *G. inflata* was entirely absent. *P. Menardii* was here represented more fully than hitherto, and by one very large specimen. Although the Foraminifera were scarce here, other forms of animal life usually met with at the same time of day were abundant.

In lat. 23° S., long. 2° E., the Foraminifera were equally abundant. *P. Menardii* were fine and plentiful; *G. bulloides* Nos. 1 and 2, *P. Micheliniana*, and *P. canariensis* were all present, together with several of *G.* (*Orbulina*) *universa*.

In lat. 22° S., long. 1° E., *P. Menardii* is found very large, and appears to be the principal form present, it seeming to have supplanted many of the others, with the exception of *G. bulloides* No. 2. *G. bulloides* No. 1 shows two or three specimens also; there was one of *G.* (*Orbulina*) *universa*; *G. inflata* not quite absent.

In lat. 21° S., long. 1° W., *P. Menardii* and *G. bulloides* No. 2 continue plentiful as before; *G.* (*Orbulina*) *universa*, *P. Micheliniana*, and *G. inflata* but show their presence: at this point the abundance of the Foraminifera appeared to end. It was during the end of April that I sailed over this portion of the ocean.

In lat. 18° S., long. 2° W., very few Foraminifera were met with—some dozen individuals of *G. bulloides* No. 2, three of *P. Menardii*, and one of *G.* (*Orbulina*) *universa*.

In lat. 15° S., long. 5° W., the same scarcity remained: one

specimen of *G. bulloides* No. 1 was found, with a few of *G. bulloides* No. 2 and *G. (Orbulina) universa.*

In lat. 15° S., long. 6° W., the same scarcity; this continued at lat. 13° S., long. 8° W.

In lat. 12° S., long. 10° W., the number of Foraminifera very slightly increased to a few of *G. bulloides* No. 2, two *Orbulinæ*, and one *P. Menardii.*

In lat. 11° S., long. 10° W., a very slight increase took place.

In lat. 3° S., long. 18° W., the Foraminifera again became abundant—*G. bulloides* No. 2 and *P. Menardii* being equally fine and plentiful, with a trace of *G. (Orbulina) universa* and *G. inflata*: this was in the night of the 12th of May.

In lat. 2° S., long. 19° W., the Foraminifera had again nearly disappeared; still there were a few of *G. bulloides* No. 2, but more of *P. Menardii.*

In lat. 1° S., long. 21° W., but a trace remained of the same forms.

In lat. 0°, long. 22° W., *G. bulloides* No. 2 became more plentiful, with traces of *G. inflata*, *G. bulloides* No. 1, and *P. Menardii.*

In lat. 2° N., long. 23° W., there were about the same number of the Foraminifera as before, consisting of *G. bulloides* No. 2 and *P. Menardii*, but the latter was here the more abundant of the two forms.

In lat. 3° N., long. 24° W., the same observations may be applied to this part.

In lat. 6° N., long. 26° W., no Foraminifera on the surface.

In lat. 7° N., long. 26° W., a very few of *G. bulloides* No. 2, with traces of *G. bulloides* No. 1, and *G. inflata.*

A few miles to the north-west of the last spot, *G. bulloides* No. 2 and *G. inflata* suddenly became more plentiful, and amongst them I noticed two specimens of *P. Menardii* and one of *G. (Orbulina) universa.*

In lat. 9° N., long. 28° W., the Foraminifera were met with in great abundance: they consisted of *G. bulloides* No. 2 and *G. inflata*, together with a fair supply of *G. (Orbulina) universa* and a trace of *P. Menardii.*

In lat. 10° N., long. 29° W., the Foraminifera were in as great profusion as I have ever met with them. *G. bulloides* No. 1 and *G. inflata* were the principal forms; but P. *Menardii* and *G. (Orbulina) universa* were well represented, and of *G. bulloides* No. 1 there were many individuals.

In lat. 12° N., long 30° W., I believe the same profusion continued; but my nets were broken.

In lat. 14° N., long. 33° W., Foraminifera still continued in great abundance. *G. inflata* was the prevailing form; there were a few of *G. bulloides* No. 2 and *G.* (*Orbulina*) *universa*; I observed also traces of *G. bulloides* No. 1, *P. Micheliniana*, and *P. Menardii*.

In lat. 19° N., long. 36° W., the Foraminifera became rare. Of *Globigerina*, *G. bulloides* No. 2 and *G. inflata* were the only forms; but I observed one individual of *P. Micheliniana*.

In lat. 20° N., long. 38° W., no traces of Foraminifera.

In lat. 30° N., long. 43° W., scarcely a trace of Foraminifera. I met with but seven individuals of *G. bulloides* No. 2. From the last spot to this, we had passed some Gulf-weed, but it was in very small quantities.

In lat. 33° N., long. 44° W., slight traces of *G. bulloides* No. 1.

On Dr. Wallich's authority, I should consider that the Foraminifera are, at times and under certain conditions, plentiful on the surface of the ocean in more northern latitudes in the North Atlantic; for he has found them abundant at the sea-bottom: (I quote from page 137) "between the Faroe islands and Iceland, between Iceland and East Greenland, and for a considerable portion of the direct route between Cape Farewell and Rockall, *Globigerina* is the prevailing form in the deposits."

It will be observed that there were places in the Indian Ocean, and also in the North and South Atlantic, where I found the Foraminifera in great abundance—occasionally for one night only, but generally for many nights in succession, although during the daytime they were absent from the surface; they did not, then, after rising once and sinking, entirely disappear from the spot, but they would on the contrary reappear nightly over many hundreds of miles of water.

Their presence on the surface did not depend entirely on the weather; for in calm nights they have been found absent, or nearly so, while in fresh blowing weather the produce of the net showed that they were plentiful.

Further observations, if recorded as the above, will show us whether the presence of the Colymbitæ is confined to certain localities, or if they are to be met with in equal abundance at different times in all parts of the ocean.

In the above list of species met with, *G.* (*Orbulina*) *universa* must be understood to include both the other subspecies, viz.

acerosa and *continens*, as, without breaking the outer chamber of every shell, the difference could not often be determined.

Note.—From the latitudes and longitudes given above, the ship's course can be readily laid down on a map; and a more graphic representation will thus be obtained of the distribution of the minute ocean-fauna than can be conveyed in words.

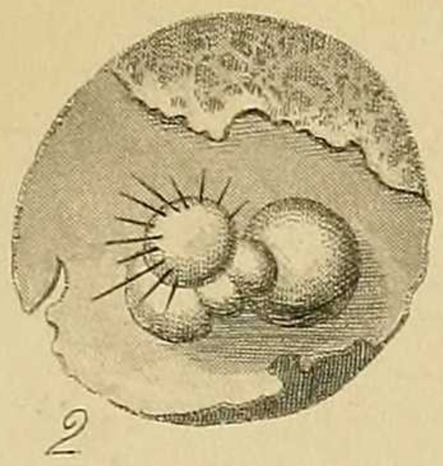
DESCRIPTION OF PLATE V.

Fig. 1. *Globigerina* (*Orbulina*) *universa.*
2. *G.* (*Orbulina*) *acerosa*, n. sp.
3. *G.* (*Orbulina*) *continens*, n. sp.
4. *G.* (*Orbulina*) *continens* broken through the internal chambers.
5. *G. hirsuta.*
6. *G. bulloides.* Form No. 1.
7. *G. bulloides.* Form No. 2.
8. *G. bulloides.* Form No. 2: reverse side of Fig. 7.
9. *G. bulloides.* Form No. 3.
10, 11. *G. bulloides.* Other varieties.
12. *G. bulloides.* Reverse side of Fig. 11.
13. *G. inflata.* A sinistral shell.
14. *G. inflata.* A dextral shell.
15. *G. inflata.* Upper surface of a sinistral shell.
16. *Pulvinulina Menardii.*
17. *P. Micheliniana.*
18. *P. crassa.* A dextral shell.
19. *P. crassa.* A sinistral shell.
20, 21. *P. canariensis.*

On the Otolites of Fish, and their value as a test in verifying recent and fossil Species. By E. T. Higgins, Esq., M.R.C.S. &c. (Communicated by G. Busk, Esq., Sec.L.S.)

[Read May 3, 1866.]

The object of this paper is an attempt to show that the otolites of fish have a certain distinctive value in determining the genera and species to which they belong, and that the close study of them in the recent forms will enable the ichthyologist to confirm or disprove the specific relationship of recent individuals, and the geologist to determine the affinity of the fossil species. In making this attempt, it will be necessary to state my belief to what extent fish possess the faculty of hearing, and, in doing so, to indicate the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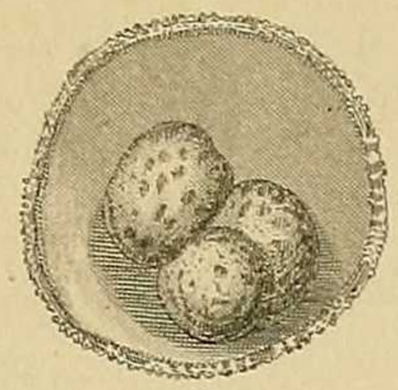
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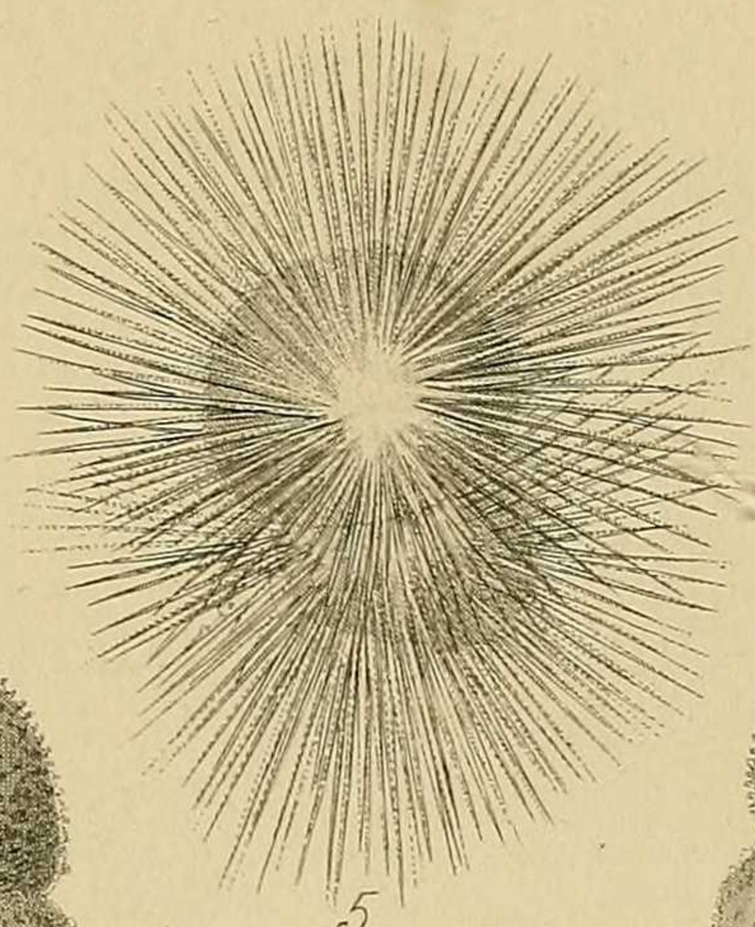
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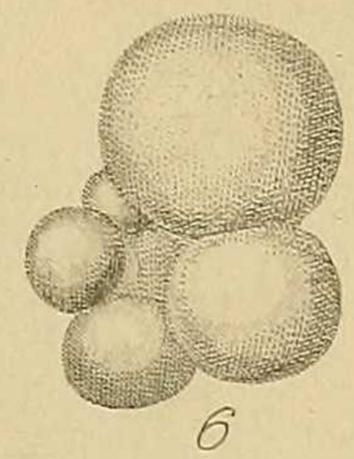
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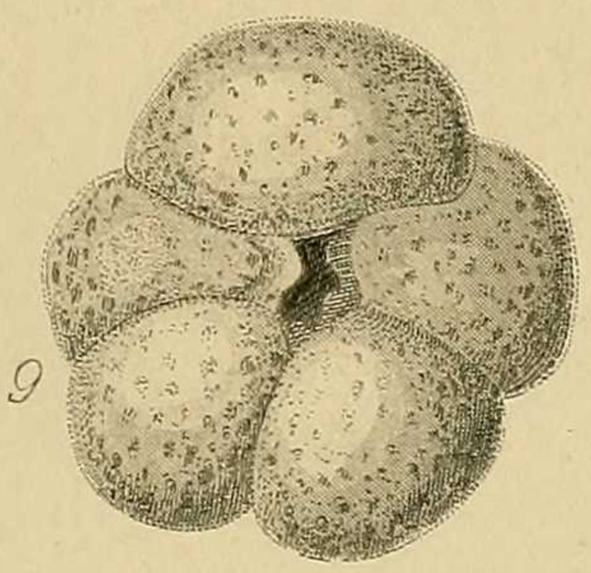
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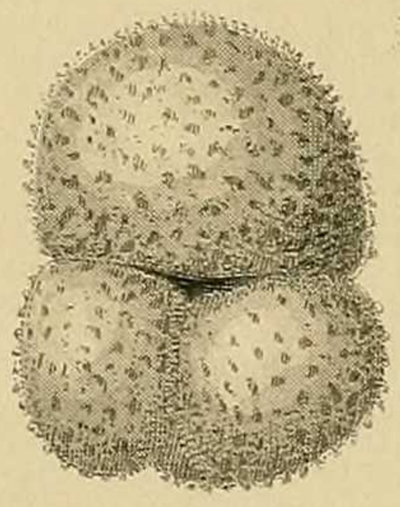
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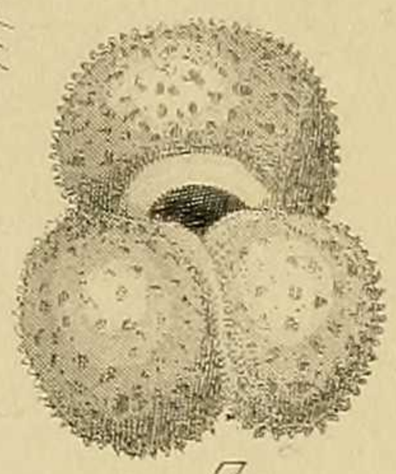
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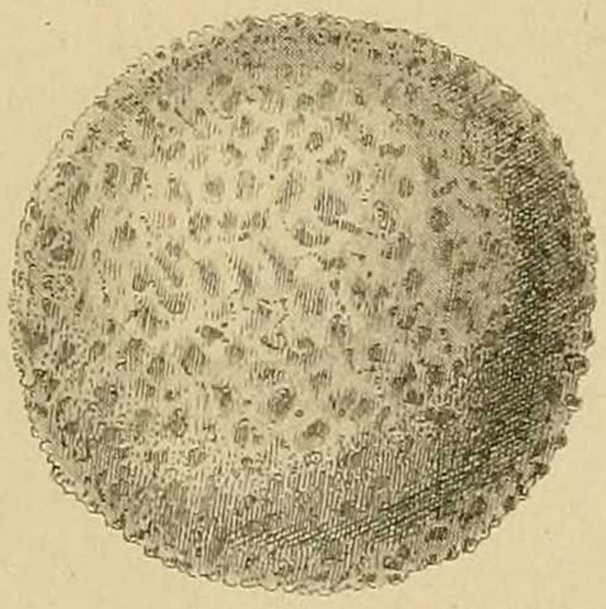
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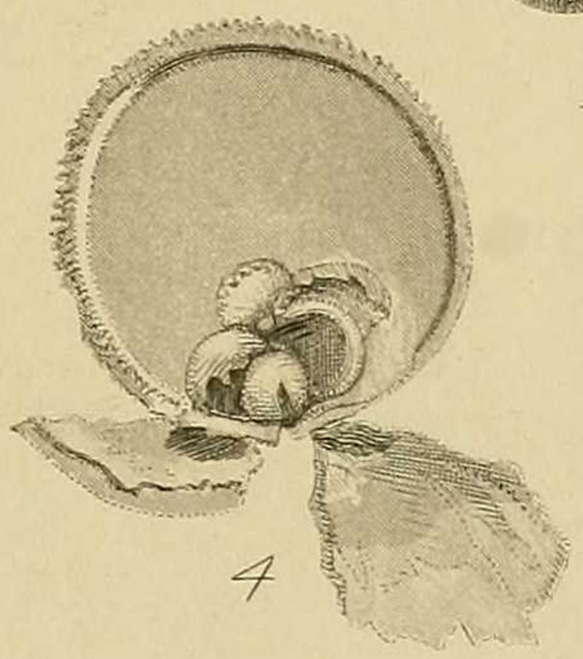
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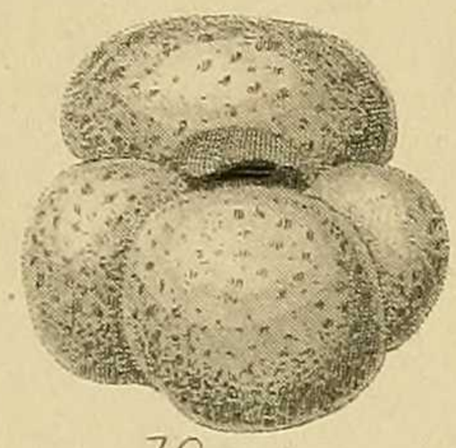
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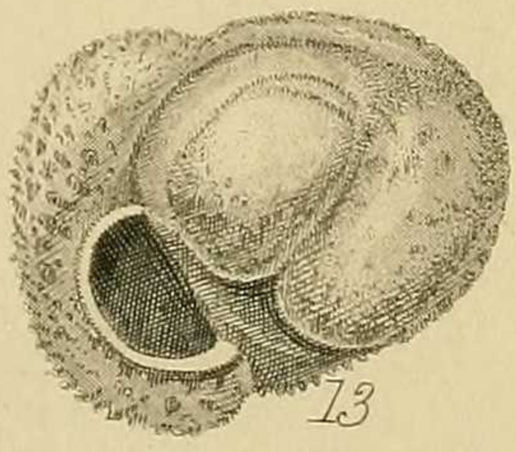
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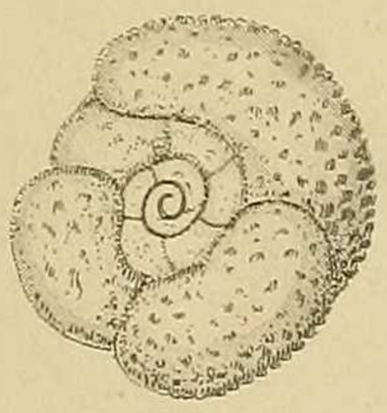
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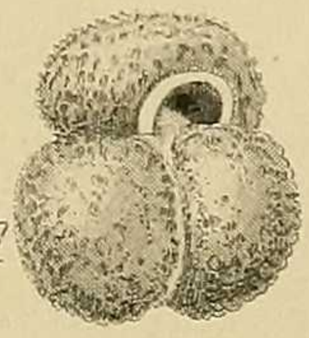
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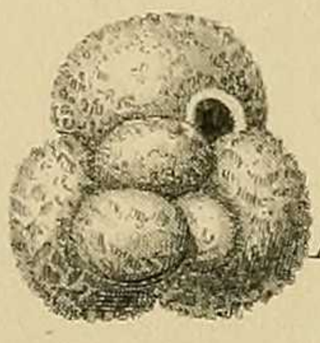
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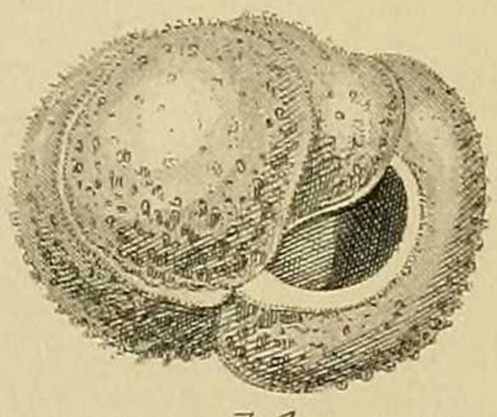
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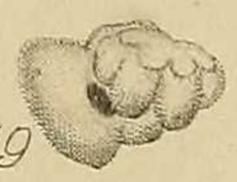
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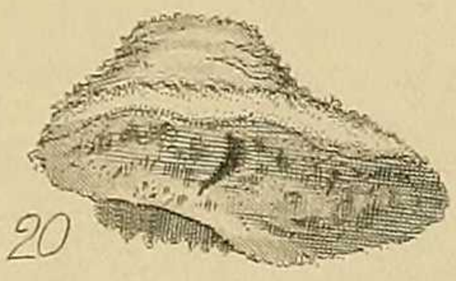
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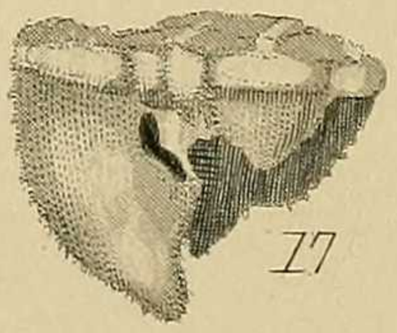
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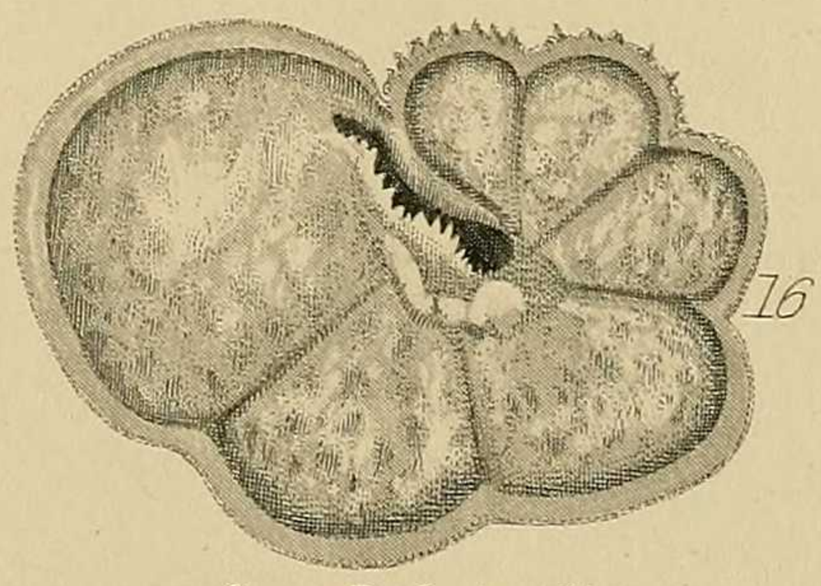
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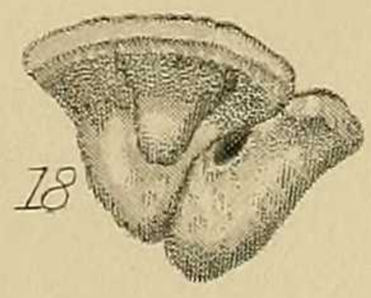
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Gen. Pulvinulina.

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