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Annals and Magazine of Natural History: Series 4

Publication details, including instructions
for authors and subscription information:
<http://www.tandfonline.com/loi/tnah10>

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Published online: 19 Oct 2009.

To cite this article: H.J. Carter F.R.S. (1871) XXII.—On Melobesia unicellularis, better known as the coccolith, *Annals and Magazine of Natural History: Series 4*, 7:39, 184-189, DOI: [10.1080/00222937108696348](https://doi.org/10.1080/00222937108696348)

To link to this article: <http://dx.doi.org/10.1080/00222937108696348>

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ever, some doubtful organisms to be worked out. The *Textularia* alluded to is a stout arenaceous variety, frequently Bigenerine in its mode of growth, and with an anomalous aperture, sometimes labyrinthic, but more frequently consisting of two or three distinct circular pores. Mr. John Young, of Glasgow, has a number of beautiful specimens of this form; and I find, in my notes on his collection of Carboniferous Foraminifera, that I have the MS. name *Textularia antiqua* appended to it.

EXPLANATION OF PLATE XII.

- Fig. 1.* A piece of *Saccammina*-limestone from Elfhills, natural size. The upper portion of the figure shows a weathered surface, the lower a fresh fracture. The white spots on the latter indicate the tufts of crystals which often occupy the interior of the chambers.
- Fig. 2.* Polythalamous specimens of *Saccammina Carteri*, natural size.
- Figs. 3 & 4.* Broken specimens showing the occasional labyrinthic structure of the inner surface of the test and the crystalline calcareous masses occupying the interior. *Fig. 3* magnified 10 diams., *fig. 4* magnified 15 diams.
- Fig. 5.* Transparent section of a segment, infiltrated partially with carbonate of lime, partially with silica: *a* is a lobe of colloid silica. Magnified 29 diams.
- Fig. 6.* A portion of the last specimen, at *a*, more highly magnified, showing the structure of the infiltrated test in transverse section. Magnified 80 diams.

XXII.—On *Melobesia unicellularis*, better known as the *Coccolith*. By H. J. CARTER, F.R.S. &c.

For some time past I have frequently noticed a cell in connexion with minute fragments of marine Sponges and Compound Ascidiae obtained from the Laminarian zone here (Budleigh-Salterton) which have been placed under the microscope for examination, also among the calcareous stellates (spicules) of the latter which have been mounted in Canada balsam; and I have as often resolved to endeavour to know more about its history when opportunity offered.

Meanwhile, having been in London in April last, I then procured, through the kindness of my friend Dr. Carpenter, a little of the deep-sea mud from the bed of the Atlantic Ocean, to see what the coccolith was, of which I had previously read Prof. Huxley's excellent account in the 'Quarterly Journal of Microscopical Science' (No. 32, Oct. 1868), and immediately recognized in the coccoliths present in this mud facsimiles of the "cell" above mentioned.

Not content, however, with Prof. Huxley's analysis or his conclusions, as I could not divest myself of the idea which this

eminent naturalist had first formed, in 1858 (*op. cit.*), viz. that it was a unicellular Alga, I still further became convinced of this, by finding it abundantly in the alimentary canal of the large Ascidian (*Ascidia arachnoidea*, Forbes & Hanley) which is thrown ashore here during storms.

Referring, then, again to Prof. Huxley's paper and accurate illustrations of coccoliths, I observed that he came to the two following conclusions, viz. :—

(1) "That they are not independent organisms, but that they stand in the same relation to the protoplasm of *Bathybius* as the spicula of Sponges or of Radiolaria do to the soft parts of those animals;" and (2) "that the coccospheres are from the first independent structures, comparable to the wheel-like spicula associated in the wall of the 'seeds' of *Spongilla*, and perhaps enclosing a mass of protoplasm [of *Bathybius*] destined for reproductive purposes" (*l. c.* pp. 210 & 211).

Now, finding the coccolith so abundant throughout the Laminarian zone here that hardly any object can be examined microscopically without its presence in greater or smaller numbers, also that in the alimentary canal of the Ascidian just mentioned it is more abundant than the frustules of Diatomaceæ or the remains of any other organism of this kind, while it is in a more or less fragmental condition, indicative of the effect of digestion, I could not help feeling still more in favour of its being an organized cell.

Hence I subjected a portion of the contents of the alimentary canal of *Ascidia arachnoidea*, in which there were many entire as well as fractured coccoliths, to the following chemical tests, watching at the same time their effect, under a glass cover, with the microscope.

(1) Solution of iodine in iodide of potassium produced no visible alteration. (2) Acetic acid, being added in sufficient quantity to more than neutralize the former, caused the calcareous cell of the coccolith to become dissolved, leaving a granular disk of protoplasm, in the centre of which was the original oval transparent area containing one or more granules, as the case might be: all the granules were of a yellowish colour, both in the disk and transparent area; and as the cell became dissolved away, so the greenish tint, which is owing to the presence of the calcareous material, also disappeared; but still no further visible change occurred. (3) The sol. iodine &c. was again let in (by the aid of a piece of bibulous paper which was placed on the opposite side of the cover); but the granules &c. still remained unaltered, and did not present the blue tint indicative of starch. (4) Finally, the acetic acid was reapplied, without further change; and after the aqueous contents had

nearly all become dried up, this was again repeated, also with no further change, the granular protoplasmic disk &c. remaining as when the acetic acid first released it from the calcareous cell.

I now turned to look at the remains of the other entire coccoliths which were present; and they were all in the same condition, with the exception of the granule (nucleus?) in the centre of the transparent area (nuclear utricle?), which was single, double, quadruple, or still more divided in different cells respectively.

Thus, still more convinced that I had a unicellular Alga under examination, and taking a portion of the little arborescent fronds of *Melobesia calcarea* ("the chalk-*Melobesia*"), which, in about ten fathoms, occurs here in accumulated beds or banks of probably miles, certainly acres, in extent, I pulverized a portion for examination, and observed several fragments whose cells, but for their polygonal arrangement, presented very much the appearance of the coccolith in their concentric lines, transparent area, and central granule, together with the absence of blue colour under the iodine test.

Lastly, considering that the coccolith is so abundant in the Laminarian zone here, and so voraciously fed upon by the Echinodermata and Ascidiae, also that it is so nearly allied in composition, structure, and habit to *Melobesia calcarea*, that it chiefly forms the bed of the Atlantic Ocean, and that it is found fossilized in the chalk, I cannot help inferring that it is a vegetable organism which contributes chiefly to form the calcareous deposits of the present day in many parts, and has done so in the formation of calcareous ones of the past, at all events that of the chalk.

With these views, then, leaving the terms "coccoliths" &c. for the fossilized forms, I would propose the following name and description for those now in existence:—

Melobesia unicellularis, mihi.

Cell calcareous, discoidal, obtusely elliptical, transparent, convexo-concave; consisting of two convexo-concave disks, one a little larger than the other, the larger one flattened on its convexity, and receiving the smaller one in its concavity; enclosing a granular protoplasmic disk with oval transparent area (nuclear utricle?), and within this a single granule (nucleus?); the granule subject to 1, 2, 4 or more division. Mode of propagation unknown. Size 1-1700th of an inch long and about 1-12000th of an inch thick.

Hab. Marine; accumulating in beds.

Loc. Atlantic-Ocean bottom; Laminarian zone, south coast of Devon. Probably universal.

Obs. There appears to be no difference between this species and the oval one of the Atlantic bed. It is also accompanied by the smaller and more simple forms designated by Professor Huxley "discoliths" (*l. c.* fig. 2, *a, b, c*), which, for reasons that will appear hereafter, I am inclined to consider immature or young specimens of *M. unicellularis*.

But there is another kind present in the mud of the Atlantic bed, which, although less plentiful, is, from its circular form (Huxley, *l. c.* p. 208, fig. 4, *a, b, c*), distinctly different from the oval *M. unicellularis*; and for this form I propose the following name and description.

Melobesia discus, mihi.

Cell calcareous, discal, circular, transparent, convexo-concave; consisting of two concavo-convex disks, one a little larger than the other, the larger receiving the smaller one in its concavity; enclosing a granular protoplasmic disk with central transparent area, which is circular and contains a granule. Mode of propagation unknown. Size about 1-2300th of an inch in diameter.

Hab. Marine, accumulating in beds.

Loc. Atlantic Ocean.

Obs. From the distinctly circular form of this species, from its being entirely absent in the Laminarian zone *here*, so far as my observation extends, and from its forming, as will be hereafter seen, exclusively the species which is present in some of the bodies described by Prof. Huxley under the term of "coccospheres," previously proposed for them by Dr. Wallich (*Annals*, 1861), I think there can be no doubt that it should have a special designation.

Coccospheres.

Seeing that the lower marine animals fed so plentifully on *M. unicellulares*, and that these as well as the coccosphere formed of them appear in the tag-like appendages of *Myxobrachia rhopalum*, Hæckel (*Quart. Journ. Microscop. Sci.* Jan. 1871, pl. 5. fig. 4), while fully aware of the rotatory motion and spherical form of the food-pellets in the alimentary cavities of the Infusoria respectively, and the globular one in which the excrementitious parts are often voided, I at first thought that the coccospheres might originate in this way; but a subsequent examination of them as they occur in the deep-sea mud (for I have never met with any *here*) has induced me to change my opinion.

In the first place, there are two kinds of coccospheres, as figured by Prof. Huxley (*l. c.* fig. 6, *c, d*); but I do not allude to his division of them into the "compact" and "loose" types. One is formed exclusively of the frustules of *Melobesia unicellularis*, and the other as exclusively of the frustules of *M. discus*—the latter, together with its frustules, much less common than the former. Then, so far as my observation goes, the frustules in the coccosphere of *M. unicellularis* vary in size with that of this coccosphere, and never attain the dimensions or fully matured appearance of the free individuals, but for the most part retain that of those called by Prof. Huxley "discoliths." As the coccospheres vary a little in size, so the largest free frustules are longer than the diameter of the smaller coccospheres, and not far short of that of the larger ones, being in the proportion of about $3\frac{1}{2}$ to $4\frac{1}{2}$ 6000ths of an inch in diameter respectively. After this, we observe that the frustules in both kinds of coccospheres are compactly tessellated over the surface of the coccosphere-cells respectively, recalling to mind the way in which the gonimic contents of a unicellular Alga (which, it should be remembered, are always confined to the periphery and situated between the cell-wall and another more delicate membrane internally, enclosing the aqueous cavity of the cell) undergo division for a new progeny (see "Fecundation of *Eudorina*," pl. 8. fig. 2, vol. ii. 'Annals,' Oct. 1858)—and, lastly, that when the calcareous material of the frustules on the coccosphere is dissolved away by acetic acid, a membranous cell (that observed by Wallich) of the same size, with a faint appearance of the frustules, still remains behind.

Now, in the face of all this evidence, how can one come to any other conclusion than that the coccospheres are the sporangia of the two species of *Melobesia* respectively above described? And may not the division of the nucleus or central granule, which we can trace in the frustules of *M. unicellularis* from a single to a multifold state, when it assumes a globular form, be in some way connected with the reproductive process, if not an early condition of the coccosphere or sporangium?

If it be satisfactorily proved that *Melobesia unicellularis* is an Alga, then both the first and second conclusions of Prof. Huxley above quoted can be no longer retained; and if the frustules of *M. unicellularis* on their coccospheres can be shown to be developed in proportion to the size of the latter, then in the lower phases they represent Prof. Huxley's "discoliths." Hence my reasons for considering the latter immature or young forms of *M. unicellularis*.

The "loose type" of coccosphere figured by Prof. Huxley

(*l. c.* fig. 7, *d*) I have not yet seen, but can easily conceive that this is a still more developed form of the sporangium or coccosphere, perhaps undergoing dehiscence.

By the use of acetic acid I have not been able to determine whether the frustules are on the inner or on the outer side of the membranous cell of the coccosphere. If the latter, then perhaps the outer cell of the sporangium is fugacious, leaving the frustules attached to the inner one, as in *Synura uvella*, Ehr. ('Infusionsthier,' Taf. 3. fig. 9; and Pritchard, 'Infusoria,' pl. 20. figs. 29, 30). We, unfortunately, know much more about the different forms of matured sporangia than we do of their subsequent development; so that our means of comparison here are necessarily very restricted.

I prefer the name of "*Melobesia*" for these cells, as this associates them with the calcareous Algæ, to which they appear to me to be most intimately allied, and for which family Lamouroux first proposed the name. The two forms cannot be considered to belong to a dioecious species, because both have their respective coccospheres.

Thus we have another organism in the Laminarian zone *here* which descends to the greatest depths of the Atlantic Ocean, to furnish food for the lower animals of that region, as it does for those at the borders of the sea. I have already pointed out, in the last number of the 'Annals,' the way in which the pachytragian shore-sponges are continued down into the deep sea through *Stelletta* (*Tisiphonia*) *agariciformis*, Sdt., = *Wyville-Thomsonia Wallichii*, Wright,—to which I might have also added the Esperiadæ, culminating in the great shrub-like branching form noticed by Dr. Carpenter, of which a specimen was sent to the British Museum; and now, while examining the portion of deep-sea mud to which I have alluded for coccoliths, I observe a representative of the Geodidæ in the presence of one of their little siliceous balls with a surface-pattern differing from any with which I am acquainted. Thus, perhaps, when all is told of this remarkable and remote locality, we may find still more instances of the connexion of living organisms on the borders of the sea with those in the greatest depths of the Atlantic Ocean.

Had Prof. Huxley had time to give his attention specially to the coccoliths, with the other advantages afforded by a sea-side residence, his antecedents show that he probably would have anticipated me in much more than I have above stated.