structure of the teeth demonstrate this since we have become acquainted with these features in that genus.

The fragment, which is upwards of $2\frac{1}{4}$ inches long, $1\frac{1}{2}$ inch wide behind, and $\frac{3}{4}$ inch wide in front, is the anterior portion of the right mandible; it has attached to it five teeth; in front it is perfect; the posterior portion is broken away close to the fifth tooth, which, though much injured, appears to be about half an inch long. The three next in advance are not quite so long, and are separated from the fifth and from each other by considerable spaces, and from the tooth in front by a space $\frac{5}{8}$ inch in length. This frontal tooth, which is perfect, is half an inch long and $\frac{3}{10}$ inch wide at the base; it is placed a little way from the extremity, where there is a depression, but whether for the reception of the base of a tooth cannot be determined. The surface of the teeth is ridged, particularly towards the base, agreeing in this respect with those in the Scotch specimen; they are a little compressed above; and one, which is tolerably perfect, has the apex slightly carinated.

On making a section of one of the teeth, it is quite obvious that the ridges on the surface are owing to erosion, if not entirely, at least mainly, and that the internal structure agrees very well with that of *Anthracosaurus* when allowance is made for the variation caused by the sections not being made at the same part. Our section was made a little way up the tooth, while those of the Scotch specimen were, as we have already explained, evidently made close to the base.

There can therefore be little doubt that this fragmentary mandible really belongs to *Anthracosaurus*. We have, then, the satisfaction of recording the occurrence in the Northumberland coal-field not only of a considerable portion of the cranium, but likewise of a large fragment of the jaw of this rare fossil.

The large sternal plate, nearly 5 inches long, described in our paper on *Pteroplax**, is probably that of *Anthracosaurus*; it was found in the same locality, and this is the only large Labyrinthodont occurring in the Newsham shale to which it can at present be assigned. We also possess some ribs and vertebræ which perhaps belong to the same animal.

XXI.—*On* Grayella cyathophora, *a new Genus and Species of Sponges.* By H. J. Carter, F.R.S. &c.

[Plate VII.]

About a fortnight since, Dr. J. E. Gray kindly sent me a specimen of a marine sponge, with the request that I would

* See Annals of Nat. Hist. ser. 4. vol. i. p. 277.

examine it, which I did; and having found it interesting in many points of view, I obtained his permission to illustrate and describe it. The sponge was originally got in the Gulf of Suez by Mr. M'Andrew, who preserved it in spirit; and the portion sent to me is that represented in the accompanying plate, magnified twice its natural size.

It is quite new both to Dr. Gray and myself; and out of respect for Dr. Gray's labours in this way, it seems to me that I cannot do better than dedicate the genus to him, and call the species, from the little coral-like cups which it bears on its surface, *Grayella cyathophora*.

GRAYELLA, nov. gen.

Grayella cyathophora, mihi. Pl. VII.

Massive, sessile, spreading. Surface undulating, smooth, interrupted by the presence of numerous subcircular, oval or conical, cup-like projections or pores, with here and there a monticular vent. Internally consisting of a distinct dermal layer covering a massive spongiform structure permeated in all directions by numerous cavities and excretory canals. Dermal layer distinct, smooth externally, bearing the cup-like bodies mentioned, with minute papillary eminences between them; consisting of condensed sarcode charged with fusiform, slightly curved, spinous spicules, and connected internally with the parenchyma by prolongations inwards of the cup-like bodies; a looser union generally in other places, between the dermal and the parenchymatous structures. Cup-like body variable in size, below the twelfth part of an inch in diameter, subcircular or oval, flat, shallow, although considerably raised above the general surface of the dermal layer by a smooth vertical wall which is continuous with the latter circumferentially, closed above by a cribriform disk, and open below in the centre, with a funnel-shaped prolongation which is extended into the parenchyma; composed of condensed sarcode like the dermal layer. Cribriform disk more or less concave, formed of a network of sarcode more or less hirsute from the projecting ends of straight, smooth, cylindrical spicules; continuous at the circumference with the wall of the cup; supported for some distance inwards on vertical columns of sarcode, which extend between it and the sides of the cup, but free in the centre, where it is spread over a compressed circular cavity that, as before stated, is prolonged, funnel-shaped, into the parenchyma; cavity in the centre of the cup formed by the cribriform disk above, by the columns of sarcode laterally, and in continuity with the funnel-shaped

prolongation below, whose surface, again, is characterized by the presence of circular rugæ of sarcode more or less reticulated, finally opening by its contracted or narrow end into the commencement of an excretory canal (Pl. VII. fig. 5); under contraction, the cup-like body is conical, puckered at the apex, and vertically ribbed to the base (fig. 9 *c*). Vents monticular, characterized by a puckered state of the dermal sarcode at their openings and more or less absence of the cup-like bodies in their immediate vicinity; consisting of a prolongation of the dermal sarcode, whose free margin more or less covers a subjacent cloacal chamber, furnished with a central elevation, from which radiate three or more septa, or as many as there may be oscular openings into this chamber (figs. 7 & 8). Parenchyma consisting of sponge-substance charged with the curved spicule mentioned, and supported on a reticulated skeleton formed of bundles of the straight cylindrical spicules, overlapping each other and bound together by non-granular transparent sarcode; superiorly attached to the dermal layer, and inferiorly to the object on which the sponge grows; permeated by small cavities and excretory canals characterized by their persistent openness and by having their walls formed of sarcodal rugæ more or less circular, prominent, and reticulated; with apertures of various dimensions in the interstices, for the most part continuous, at their commencement, with the constricted funnel-shaped prolongations of the cup-like bodies, presenting cavernous dilatations here and there in their course, and finally, after uniting to form large trunks, opening by the oscula into the chambers of the vents already described. Spicules of two kinds, long and short; the former just three times the length of the latter. Long spicule smooth, straight, slightly fusiform, almost cylindrical, abruptly terminated, with one end a little sharper than the other; confined to the skeleton-structure of the parenchyma and the sarcodal columns of the cup-like bodies. Short spicule abundant, thickly spinous, slightly curved, fusiform, sharp-pointed, confined to the parenchyma and dermal layer; spines minute, erect, pyramidal. Size of specimen figured $1\frac{1}{2}$ inch long by $\frac{1}{2}$ inch thick; original mass much larger. Colour not stated.

Hab. Red Sea, Gulf of Suez. Sessile, spreading on rocks or hard surfaces.

Obs. This is a very remarkable sponge, for many reasons. In the first place, the cup-like bodies so much resemble those of similar corals, especially when the former are rendered conical and ribbed by contraction, that, in a fossilized state, the cribriform disk alone could determine the point; and to a superficial observer the specimen, even when recent, might

thus easily be mistaken for a coral. It did not, however, escape the keen discrimination of Mr. M'Andrew; and hence we are provided with a species which at once brings the sponges a step nearer to the corals *in form*, and one which may now and hereafter throw much light on the true nature of many fossilized species that otherwise might be doubted.

The cup-like body, averaging in its broadest diameter 1-12th of an inch, far surpasses in size anything of the kind hitherto met with in the sponges. Witness a similar apparatus which I have lately described and figured in *Pachymatisma Johnstonia* (Annals, this volume, pl. 2. fig. 12 &c.), where it is depressed and not more than a quarter the diameter of the cup-like body in *Grayella cyathophora*.

This, too, I think, is the first instance on record where the pore (for such is the nature of the cup-like body) has been shown to be in direct communication with the excretory canals.

Although the surface of the dermal layer between the cup-like bodies is minutely papillated, and each papilla might, in the recent state, have presented an aperture, which the sponge itself, or the astringency of the spirit in which it was preserved, may have closed, I only saw one here and there; and these were as often in the depressions between as upon the papillæ themselves. Hence I am inclined to infer that such apertures are adventitious. In some instances they appear to be the buds of new cups; but for the most part the dermal layer is perfectly smooth, and hirsute only over the cribriform disks.

The cups, again, have the power of closing themselves; but whether this is produced by the general contraction of the reticulated sarcode of the cribriform disk, or by that of the walls of the cup alone, or by both synchronously, I am ignorant. When, however, it does take place, the cups, in successive degrees of contraction, show that the apertures of the cribriform disk are more or less closed by the approximation of the reticulated structure; and the margin generally yielding as well, causes the cup to assume a conical form, puckered at the apex and ribbed vertically down its sides, in the manner of a coral-polype (fig. 9 *a*, *b*, *c*).

After the water has passed through the concave cribriform disk (convex or flat when living?), it reaches the internal cavity or chamber of the cup, and thence flows on to the constricted end of the funnel-shaped prolongation, which, being provided with the circular ribs or rugæ of sarcode mentioned, may also have the power of total closure, especially at the point where it opens into the commencement of the excretory canal to which it is attached (fig. 5 *c*, *f*).

The excretory canal, too, is observed to be much wider than

the constricted end of the funnel which here joins it, and to be formed, apparently, of much less rigid structure. The sarcodal rugæ are much more openly reticulate, although still tending to a circular arrangement; and apertures of different dimensions begin to appear in the interstices of the reticulation (fig. 5 *g*, *h*, *i*).

One cannot help being struck with the resemblance in form of these rugæ (which are indistinctly fibrous under compression and a high power) to the *carneæ columnæ* of the heart in warm-blooded animals; nor can one help associating the patent character of the canals with this structure surrounding them, and the apertures in the interstices, with the tracheæ of insects. We see also how the extent of surface thus becomes multiplied, how these projecting rugæ assimilate the structure to that of the frog's lung, where, for aëration, the internal surface of the hitherto simple sac in fishes begins to shadow forth the vesicular character and vast extent of surface exposed for aëration in the fully-developed lungs of the mammalia; nor can we, finally, fail to conclude that the excretory system of canals in this and probably all other sponges may, at least partly, subserve this purpose.

I have not been able to pass a bristle from the vent on the surface through the excretory canal in the parenchyma to the cribriform disk of the cup-like body, or *vice versâ*. Neither could it be expected, with so many loose valvular projections intervening, and such tortuous passages, that the top of a bristle would be thus unimpeded in its transit. But a bristle can be easily passed through the truncated ends of the large excretory canals in the parenchyma to the vent on the surface; and when these canals are compared with the canals into which the funnel-shaped prolongation of the cup-like body empties itself, their structure is found to be identical. If this identity alone be not considered sufficient to establish the fact that the cup-like body opens directly into an excretory canal, then the fact that there are no other canals of the kind in the sponge for it to open into but the excretory system is decisive. The bristle for this purpose should be burnt at one end, to give it a round form, or "probe-point."

We next come to the apertures opening into the excretory canal itself through the interstices of the sarcodal reticulations; and this brings us to the subject of nutrition, with which the excretory system, in combination with the cup-like bodies, must be as much connected as with aëration (fig. 5 *i*).

No doubt many of these apertures are the openings of branches of the excretory canal-system which may belong to as many cup-like bodies; but then there are others which

seem too minute for this. In short, there are many more apertures than there are cup-like bodies; so we have to account for the superfluity.

It is evident that Prof. Huxley's hypothetical diagram (Introduct. to the Classification of Animals, p. 15, fig. 4), by which a globular cavity lined with ciliated sponge-cells is made to have two apertures (viz. one receiving a stream of water directly from the exterior, and the other transmitting it into the excretory canal), will not apply to *Grayella cyathophora*. We must have another hypothesis here, more especially for the canals which do *not* communicate with a cup-like body.

Certainly, in the young *Spongilla*, growing from the seed-like body, the particles of food (carmine) may be seen to pass into the general chamber surrounding the parenchyma, and thence into ampullaceous sacs imbedded in the latter. That these sacs are lined with monociliated and unciliated sponge-cells which incept the particles, apparently transmitted through a single aperture in this sac, is also evident. But I could never see how the undigested portions got into the excretory canals. I had therefore to conceive that it took place through the bodies of the sponge-cells themselves, as a particle might be incepted on one side of an *Amœba* and ejected at the other—in short, that the sponge-cells of the ampullaceous sac acted as a kind of partition between the chamber receiving the particles and the canals carrying off the refuse. (See my figures and descriptions of the ultimate structure of *Spongilla*, Annals, ser. 2. vol. xx. p. 21.)

But, be this as it may with *Spongilla*, it is with *Grayella cyathophora* that we are now chiefly concerned; and here, although it is plain that there is a direct communication between the cup-like body and the excretory canal, it is equally plain also that this is chiefly for aëration and for the admission of nutritive particles to some other organs.

We have therefore to look for these organs; and falling back upon the canals which do not come directly from the cup-like bodies, and certain cavernous excavations in the parenchyma above mentioned, which appear to be dilatations of the excretory canals along their course, analogous to, if not homologous with, the areolar cavities in *Pachymatisma Johnstonia* (Annals, this volume, pp. 12 & 13), it does not seem improbable that the sponge-cells which incept the particles may be here situated.

But whether they are in vesicular dilatations (like the "ampullaceous sac") at the ends of these canals, or whether in globular dilatations like those in Prof. Huxley's hypothetical

diagram, situated on canal-loops which have thus two openings in connexion with an excretory duct, future discovery must determine.

It is useless to attempt this in a sponge which has been preserved in spirit, or in any other way after death; for the sarcode is too delicate to retain the form of its minuter parts unaided by vitality. Hence it is necessary to pursue these researches with the sponge in the living condition, and under experiments perhaps similar to those instituted by myself in the examination of *Spongilla*, whose ultimate structure, so far as I have gone, never could have been obtained under any other circumstances. In the present instance, however, we may consider ourselves fortunate in having met with a species in which the continuity of the pore or cup-like body and the excretory canal can be clearly demonstrated even after preservation.

Another question, which can only be determined during life, is the form and nature of the sponge-cell engaged in the nutritive function.

In Prof. James-Clark's valuable paper (Memoirs of the Boston Society of Nat. History, read June 20, 1866, and reprinted in the 'Annals,' 1868, ser. 4. vol. i.), it is naturally urged that, because the ciliated cells of the calcareous sponge called *Leucosolenia botryoides* have a funnel-shaped process round their cilium, and particles drawn by the cilium into the funnel pass thence into the body, they are taken into the latter through a fixed oral aperture, close to which also the undigested portions make their exit, as in his genus *Codosiga* &c., among the flagellated Infusoria. Further, Prof. James-Clark thinks it not improbable that such might be the case with the ciliated cells of *Spongilla* possessing the ear-like appendages which I have figured in the 'Annals' (ser. 3. vol. iii. pl. 1. figs. 12, 13, 14), these being, in his opinion, merely the sides in profile of the funnel-shaped process not otherwise seen—an appearance which he himself has recognized. But it may be observed that, among the sponge-cells of the "ampullaceous sac" of *Spongilla* (*l. c.*), there were not only monociliated but also unciliated sponge-cells which had equally incepted the particles of carmine. It is possible that the funnel-shaped process and the cilium may have been retracted here, in accordance with Prof. James-Clark's observations of the latter in *Codosiga* (p. 193, *l. c.*) and of the former in *Leucosolenia* (footnote, p. 208, *ib.*); and this might be his explanation of their absence, the oral orifice remaining fixed and stationary as before. Still such retraction would not be less characteristic of the Rhizopoda than of the Infusoria flagellata.

But Prof. James-Clark, in alluding to my statement that the sponge-cells are allied to the Rhizopoda, from the probability of their having no fixed oral aperture but the power of polymorphism and the inception of particles of food at any point of the body &c., announces his "firm conviction that the true ciliated *Spongiæ* are not Rhizopoda in any sense whatever, nor even closely related to them, but are genuine compound *flagellate Protozoa*" (*l. c.* p. 206). To what extent the "true ciliated *Spongiæ*" may be carried does not appear, although it seems evident that the expression includes the calcareous sponges.

Now, a short time since, having had to break up, for microscopical examination, a living portion of a calcareous sponge, viz. *Grantia ciliata*, which is closely allied to *Leucosolenia*, I observed that, after a little while, the cilia ceased to appear (were retracted?), and that the cells all began to creep about the glass by expansions identical with those of *Amœba*. Hence I still, even among the calcareous sponges, must adhere to my opinion that they as well as *Spongilla* are closely allied to the Rhizopoda.

Prof. James-Clark assumes, on the inferences above stated (for he did not actually see the oral aperture either in the cells of *Leucosolenia* or *Codosiga*), that there is a fixed mouth and an anal orifice close by it, and therefore that the animal expression (if I may use the term) of the "true ciliated Spongiæ" is a flagellated Infusorium not allied to the Rhizopoda "in any sense whatever."

I also, on inferences above stated, assume that the sponge-cell is almost identical with *Amœba*, and therefore that all the sponges are intimately allied to the Rhizopoda.

It is but fair, however, to add that I have not yet had time to search for the signs of the flagellate Infusoria delineated and described by Prof. James-Clark, viz. the funnel-shaped process surrounding the cilium &c., and therefore am not able to confirm or disprove his conclusions in this respect. At the same time, I think, the fact of the amœboid organisms beginning life as flagellated Infusoria, and afterwards exchanging (retracting?) the cilium for a polymorphic condition, if they do not occasionally present both forms in combination, points to a nearer alliance between the two than Prof. James-Clark's "conviction" above quoted would allow.

Lastly, the formation of the vents in *Grayella cyathophora* is peculiar; for the oscula do not open directly upon the dermal layer as in most other sponges, but into a cloacal chamber which is formed over them by a prolongation of the dermal sarcode, evidencing by its puckered orifice that it also

has the power of opening and closing itself as occasion may require (figs. 7, 8).

EXPLANATION OF PLATE VII.

Fig. 1. *Grayella cyathophora*, n. sp., magnified twice the natural size; showing cup-like bodies or pores and vents.

Fig. 2. The same, small spinous curved spicule of the dermal layer and parenchyma, magnified. Size 7-1800ths long by about 1-8000th inch broad.

Fig. 3. The same, portion of spinous spicule more magnified, to show form of spines.

Fig. 4. The same, large, smooth, straight spicule of skeleton and cup-like body, magnified. Size 20-1800ths long by about 1-6000th inch broad.

Fig. 5. The same, vertical section of one of the cup-like bodies, greatly magnified (scale 1-48th to 1-1800th of an inch): *a a*, cup; *b b*, its continuity with the dermal layer; *c c*, cribriform disk supported on sarcodal columns, in which are imbedded the smooth spicules whose ends project beyond the surface; *d*, portion of cribriform disk covering the cavity or central chamber of the cup; *e*, vertical section of funnel-shaped prolongation of central chamber, showing its circular rugæ; *f*, its constricted end opening into *g*, the commencement of an excretory canal; *h*, reticulated sarcodal rugæ, characteristic of the internal surface of the excretory canals; *i*, apertures opening into excretory canal between the reticulations of the sarcodal network.

Fig. 6. The same, cribriform disk magnified on the same scale. Foramina varying from 1-1800 to 1-300th of an inch in diameter.

Fig. 7. The same, vertical section of vent, greatly magnified and diagrammatic, to show:—*a*, opening of cloacal chamber; *b*, prolongation of dermal layer forming the sides of the chamber; *c*, papillary eminence in the centre of the chamber, from which radiate as many septa to the sides of, as there are oscula opening into, the chamber; *d*, *d*, portions of chamber leading down to oscula.

Fig. 8. The same, horizontal section of vent, greatly magnified and diagrammatic, to show:—*a*, external surface of dermal prolongation forming cloacal chamber; *b*, cut edge of same; *c*,*c*,*c*,*c*, openings of oscula; *d*, horizontal section of papillary eminence and septal divisions.

Fig. 9. The same, portion of dermal layer, to show three cup-like bodies in different degrees of expansion and contraction respectively, magnified 6 diameters; also the minute papillary elevations between them: *a*, fully expanded cup; *b*, half-expanded cup; *c*, wholly contracted cup, showing its ribbed coral-like form from contraction; *d*, minute papillary elevations on dermal surface.

Fig. 10. The same, portion of dermal layer, magnified, to show the disposition of the small spinous spicules with which it is charged.

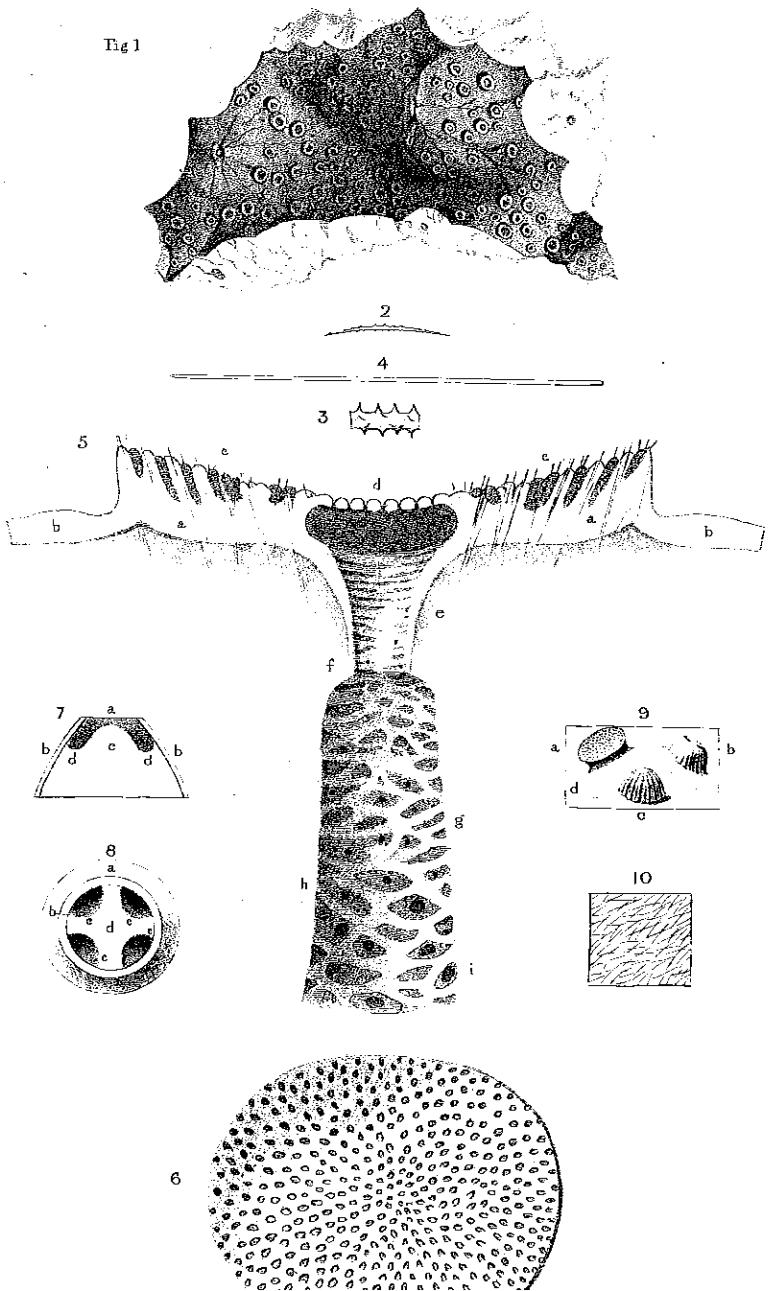
Fig 1
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