XXVIII. *On a new Crinoid from the Southern Sea.*

By P. Herbert Carpenter, *M.A., Assistant-Master at Eton College.*

Communicated by William B. Carpenter, *C.B., M.D., F.R.S.*

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Received March 15,—Read April 12, 1883.

[Plate 71.]

Towards the end of last year I received from Mr. Murray a small collection of "Challenger" *Comatulæ* which had been retained by the late Sir Wyville Thomson, and was found among his other collections after his death. It included several duplicates of forms already known to me, among them being three fairly perfect specimens of a type which I had only been able to study from a mutilated calyx. There were also eight or nine new species of *Antedon*, all from stations which had already yielded *Comatulæ*, two of them abundantly so. Lastly, there was an apparently insignificant little specimen from a depth of 1,800 fathoms at Station 158 in the Southern Sea.* It has five simple arms, and appeared at first sight to be merely a young individual of *Eudiocrinus semperi*,† which was dredged at Stations 164 and 169. Upon closer examination, however, I found that the specimen, although a true *Comatula*, and resembling *Eudiocrinus* in having but five arms, presents two characters which occur in no other Neocrinoid. In fact it is only among some of the older Palæocrinoids that similar features are to be met with, and I have no hesitation in saying that this is by far the most remarkable of all the Crinoids obtained by any of the recent deep-sea exploring expeditions.

Under these circumstances I propose to distinguish the type by the generic name *Thaumatocrinus*,‡ with the specific designation *renovatus*.

* Station 158, March 7, 1874, lat. 50° 1′ S., long. 123° 4′ E.; depth 1,800 fathoms; bottom temperature 3° C., Globigerina-ooze. The only other *Comatula* obtained at this station was *Promachocrinus abyssorum*.

† This is the *Ophiocrinus semperi* of my preliminary report (Proc. Roy. Soc., No. 194, 1879, p. 385). Owing to the previous employment of *Ophiocrinus* by Salter and also by Angelin, I have proposed *Eudiocrinus* for the recent type to which this name was given by Semper (Journ. Linn. Soc. Zool., vol. xvi., p. 493).

‡ *θαῦμα*, a marvel.

The total width of the calyx across the disc is barely 2 millims.; and the height of the centrodorsal and radials together is about the same. The former (Plate 71, figs. 1–4, *cd*) is rounded below, with its central canal completely closed up, so that it must have been detached for some little time from the remainder of the stem. The bases of half a dozen cirri are attached to it, and there are pits for the reception of two or three more. In the largest stump which is preserved (Plate 71, figs. 1, 3, *c*) the first two joints are quite short, as is usually the case, but the third reaches a length of 1·5 millim., so that the cirri must have been very like those of *Eudiocrinus semperi*. Except in this respect, however, and in the presence of five undivided arms, there is no further resemblance between the two types; for *Eudiocrinus* has a rosette, and consequently no basals appear externally. The radials are also only partially visible, owing to the extension of the centrodorsal over their lower surfaces, and the oral plates of the larva do not persist in the adult. But in *Thaumatocrinus* (Plate 71, figs. 1–4) there are relatively large basals (*b*), which completely separate the centrodorsal (*cd*) from the radials (*r*). This is itself an unusual feature in any *Comatula*, as will be explained further on.

Upon these five basals there rests a ring of ten arched plates, five of which (*r*) bear the arms, and are evidently the radials. But they *are not in contact laterally*, as is the case in every other five-rayed Neocrinoid with which I am acquainted, for they alternate with five smaller plates (*i*, *i*), which rest upon the truncated apices of the basals, while the radials rest in the angles formed by the adjacent sides of every two contiguous basals. Four of these five interradial plates terminate in a free edge at the margin of the disc; but the fifth, that on the anal side, bears a small tapering appendage of four or five joints, the last of which seems to end freely (Plate 71, figs. 2, 4, 5, *aa*).

The arms are composed of somewhat elongated joints, the second of which (Plate 71, figs. 1, 2, 4, b_2) bears the first pinnule. This is on the right side in three arms, and on the left in the other two. A similar variation occurs in *Eudiocrinus semperi*, but I do not attach much importance to it. The pinnules are very slender and delicate.

The disc resembles that of *Hyocrinus*. Its central portion is occupied by a relatively large oral pyramid (Plate 71, fig. 5, *o*), while between this and the margin are two or three irregular rows of small anambulacral plates (Plate 71, figs. 1–5, *an*), some of them extending up on to the lower part of the long anal tube (*at*). The large size and comparatively dense appearance of these orals indicates that they are not undergoing the process of resorption as those of other *Comatulæ* do. In some species (*e.g.*, *Ant. dentata*, SAY = *A. sarsi*, DUB. and KOR.) the process is completed long before the end of the pentacrinoid stage; but in *Ant. rosacea* the orals persist in a partially resorbed condition after the loss of the stem, though they soon disappear completely.

Thaumatocrinus is thus the only *Comatula* yet known in which the oral plates of the larva persist, as they do in *Hyocrinus* and *Rhizocrinus*. The other peculiarities

which it exhibits are (1) the appearance of a closed ring of basals on the exterior of the calyx; (2) the separation of the radials by inter-radial plates; (3) the presence of a jointed arm-like appendage on the inter-radial of the anal side.

The persistence of the oral and basal plates of the larva, together with the small size of the specimen, might be thought to indicate that *Thaumatocrinus* is merely a type in which the resorption of the orals and the metamorphosis of the basals into a rosette take place unusually late. But as I have already pointed out, the condition of the centrodorsal, and of the cirri which it bears, is evidence that the specimen must have been detached from its stem for some little time, while the orals show no signs of any approaching resorption. The existence of the interradials also decidedly indicates that the basals on which they rest form a permanently closed ring on the exterior of the calyx. This is the case in but a very few *Comatulæ*, either recent or fossil.

SCHLÜTER mentions a Cretaceous species in which it occurs;* while there are several forms, both of Cretaceous and of Jurassic age, in which the basal ring is incomplete, and the radials partly rest on the centrodorsal. But the only recent type in which the basals remain visible on the exterior of the calyx is the curious genus *Atelecrinus*;† and here they are very small in proportion to the radials. In all other recent *Comatulæ* the basals disappear from the exterior of the calyx towards the end of Pentacrinoid life, and become transformed into the rosette. Some species remain much longer in the Pentacrinoid stage than others; so that of two calices of equal size, the one may be still attached to a stem, the top joint of which bears but a few rudimentary cirri, and have large basals; while the other has a centrodorsal bearing 15 or 20 cirri, and concealing both the basals, and a part of the first radials. *Antedon rosacea* and *A. dentata* (*A. sarsi*, DUB. and KOR.) are two excellent instances of this difference, the latter attaining a length of 40 millims. in the Pentacrinoid state. A similar condition is presented by a Pentacrinoid which was dredged by the "Porcupine," and is probably to be referred to *Ant. eschrichti*, or to *Ant. quadrata*.‡ It is stouter and altogether more robust than any larva of *Ant. dentata* which I have seen; and though its radials are as large as those of the free *Thaumatocrinus*, yet its basals are actually higher than those of the single specimen of the latter type; while the centrodorsal on which they rest has merely a few imperfect cirrus-stumps, and is scarcely larger than the stem-joints below it. On the other hand, another larva from near Ascension (S. 344; 420 fathoms) has equally large radials resting directly on the centrodorsal, which bears about eight well-developed cirri; but the basals have already disappeared from the exterior of the calyx. An earlier stage in the development of this same larva is shown in Plate 71, fig. 6, for comparison with *Thaumatocrinus*. Although the calyx and arms are well developed, the basals (*b*)

* Zeitschr. d. Deutsch. Geol. Gesellsch., Jahrg. 1878, p. 66.

† Bull. Mus. Comp. Zoöl., vol. ix., No. 4, 1881, p. 16, pl. i., figs. 1–7.

‡ This is the *Ant. celtica* of MARENZELLER, and of DUNCAN and SLADEN; *non* BARRETT.

separate the radials (*r*) from the centrodorsal (*cd*), which is, as yet, but slightly differentiated from the stemjoints below it. In all cases, however, the basals become concealed very soon after the conclusion of the Pentacrinoid stage, if not before. I can find no trace of them in various abyssal *Comatulæ*, which are no larger than *Thaumatocrinus renovatus*, and suspect therefore that in this type they persist through life as they do in *Atelecrinus*. Were they really only larval basals, and destined to have been eventually transformed into a "rosette," *Thaumatocrinus* would present a still more curious combination of characters than it actually does.

Both the persistence of the basals and the considerable development of the orals are characters which, either singly or combined, would cause the type to be regarded as one of no little interest; but they are altogether cast into the shade by the other peculiarities of the calyx, viz., the complete separation of the radials by relatively large interradial plates, and the presence of the anal appendage.

It might perhaps be suggested that the ten-rayed *Promachocrinus* affords some explanation of the first of these points. In this genus * the basals only exhibit a pentamerous symmetry, for the rosette into which they become transformed is connected with a basal star of five rays only, just as in any other *Comatula*. These five basal rays are attached to the dorsal surfaces of five out of the ten radials so as to partially separate them from the centrodorsal. These radials, therefore, are really interradial in position, and so correspond to the five interradial plates of *Thaumatocrinus*. But here the resemblance ceases; for the "interradial radials" of *Promachocrinus* precisely resemble the five true radials with which they alternate, and the arms borne by the two sets of plates are indistinguishable. I cannot, therefore, regard *Promachocrinus* as anything but a very regular variation of the usual pentamerous symmetry of the Crinoids.

Failing *Promachocrinus*, there is no other Neocrinoid which presents anything like the remarkable morphological condition of *Thaumatocrinus*. To find a corresponding developmental stage we must go back to a very early period in the ontogeny of a Crinoid, *i.e.*, one but little later than the appearance of the rudiments of the lowest arm-plates. The radials first appear as isolated plates in the spaces "where the upturned angles of two oral plates are opposed to the bevelled off upper angles of two adjacent basals."† They gradually increase in size, and ere long come to form a nearly complete circle, two of them being separated for a time by the anal plate. This is eventually lifted out from between them, but the radials of *Ant. rosacea* do not come into complete lateral contact until after the appearance of the first whorl of cirri. In the larva represented in Plate 71, fig. 6, however, the cirri do not appear until the radials have met laterally, and the arm-bases are well developed. The radials of a mature *Comatula*, therefore, form a closed ring of five plates; and any interradials which may subsequently appear are limited to the angles between adjacent second

* Proc. R. S., No. 194, 1879, p. 385; see also Journ. Linn. Soc. Zool., vol. xv., p. 214, pl. 12, fig. 28.

† C. Wyville Thomson, "On the Embryogeny of *Antedon rosaceus*," Phil. Trans., 1865, p. 528.

and third radials, though sometimes attaining a considerable relative size and importance, as in *Guettardicrinus* and some species of *Apiocrinus*.

It is well known that many peculiarities which are merely transitory in young larvæ of the Neocrinoids, are permanently retained in some of the Palæocrinoids. This is the case, for example, with the primitive position of the anal plate within the ring of (first) radials of the larval *Antedon*. Thus in the Devonian genus *Hexacrinus* (AUSTIN), and in some allied forms from the Carboniferous limestone among the *Platycrindæ*, two of the five radials are separated permanently by a single large anal plate; and the still earlier condition, before the radials have come into lateral contact at all, finds a parallel in the remarkable genus *Reteocrinus*,* from the Trenton and Hudson River groups (Lower Silurian) of North America. In this type, however, the radials are separated by what Messrs. WACHSMUTH and SPRINGER † describe as an "interradial series resting directly upon the basals, consisting of a very large number of minute pieces of irregular form, and without definite arrangement." A similar development of small irregular plates between the rays occurs in many Neocrinoids, both stalked and free, but the interradial series always commence at the level of the second or third radials, and are completely separated from the basals by the ring of united first radials.

Now in *Thaumatocrinus* we not only find the primitive lateral separation of the radials to be permanent, as in *Reteocrinus*, but instead of the small and irregular interradials which rest on the basals of that type, *Thaumatocrinus* has one relatively large plate between every two radials (Plate 71, figs. 1–4, *i*, *i*). This is, as it were, a further development of the embryonic condition, but in a new direction. It is, however, one which is not to be found in any Neocrinoid, either recent or fossil, and it is only among certain of the Palæozoic *Rhodocrinidæ* that a similar peculiarity presents itself. Messrs. WACHSMUTH and SPRINGER have grouped the genera in which it occurs into a special section, *Rhodocrinites*.‡ They are *Lyriocrinus* (HALL); *Rhipidocrinus* (BEYRICH); *Thylacocrinus* (OEHLERT); *Anthemocrinus* (W. and S.); *Rhodocrinus* (MILLER); and *Ollacrinus* (CUMBERLAND). All of them have a ring of ten plates resting on the basals, viz., the radials and five interradials of about the same size. This is well shown in the diagram of the calyx of *Thylacocrinus* (Plate 71, fig. 7), which I have copied from that given by OEHLERT.§

While resembling the *Rhodocrinites* in having five large plates separating the radials, *Thaumatocrinus* differs from them, and from most Palæocrinoids, in the absence of any higher series of calicular interradial plates resting upon the first series which

* Of BILLINGS, *emend.* WACHSMUTH and SPRINGER.

† "Revision of the Palæocrinoidea," Part II., p. 192. From the Proceedings of the Philadelphia Academy, July 26, 1881, p. 366.

‡ *Ibid.*, pp. 182–184.

§ "Description de deux nouveaux genres de Crinoïdes du terrain dévonien de la Mayenne." Bull. Soc. Géol. de France. 3e Ser., Tom. vii., pl. 1., fig. 2.

separate the radials. Except on the anal side, these primary interradial plates of *Thaumatocrinus* end simply in a free rounded edge at the margin of the disc (Plate 71, figs. 1–3, 5, *i*), which is doubtless due to the simplicity of the arms; for these become free almost at once, and are not connected laterally by much perisome, in which higher orders of interradials could be supported. But in the presence of the appendage on the azygous interradial (Plate 71, figs. 2, 4, 5, *aa*), *Thaumatocrinus* bears a remarkable resemblance to *Reteocrinus*. The latter genus was established by BILLINGS on some badly preserved fragments from the Trenton limestone of Ottawa.* MEEK, and WETHERBY have since described some species of *Glyptocrinus* presenting very similar characters to those of BILLINGS' genus, and have noted the resemblance between them; while WETHERBY† subsequently came to the conclusion "that several forms of our so-called *Glyptocrinus* should be referred to this genus." WACHSMUTH and SPRINGER‡ have accordingly reconstructed *Reteocrinus*, and have proposed as type of the genus *Glyptocrinus nealli* (HALL), a proceeding for which they have been severely criticised by MILLER.§

The original examples of BILLINGS' type species were so imperfectly preserved, that the distinctive characters of his genus were incompletely known. As, however, WACHSMUTH and SPRINGER, like WETHERBY, fully believed *Glyptocrinus nealli* to be a *Reteocrinus*, I do not see how they could have redefined the genus better than by selecting such a well-known species as their type.

Taking *Reteocrinus* then as defined by WACHSMUTH and SPRINGER, we find that its posterior interradial area is wider than the other four, "with a conspicuous row of decidedly larger and more prominent special anal plates along the median part." BILLINGS gives a good figure of this structure in *R. stellaris*,‖ and speaks of it as follows: "If this series of joints constitute a true arm, then there must be six arms in this species." The same feature appears, though less prominently, in *R. nealli* (HALL) sp., and in *R. baeri* (MEEK) sp., and also in *R. richardsoni* (WETHERBY), though in *R. gracilis* (WETHERBY) and *R. cognatus* (MILLER) sp., it appears to be absent. It is unusually distinct, however, in *Xenocrinus penicillus* (MILLER)¶ (Plate 71, fig. 8), a type which closely resembles *Reteocrinus* in general appearance; and I fully agree with Messrs. WACHSMUTH and SPRINGER** in thinking that it should

* 'Canadian Organic Remains.' Decade iv., p. 63.

† "Description of new Fossils from the Lower Silurian and Subcarboniferous Rocks of Ohio and Kentucky." Journ. Cincinnati Soc. Nat. Hist., vol. iv., April, 1881, p. 7 (of separate copy).

‡ Revision. II., p. 191.

§ "Description of Two New Genera and Eight New Species of Fossils from the Hudson River Group." Journ. Cincinnati Soc. Nat. Hist., vol. v., April, 1882, pp. 12, 13 (of separate copy).

‖ *Op. cit.*, p. 64, pl. 9, fig. 4*a*.

¶ "Description of Some New and Remarkable Crinoids and other Fossils of the Hudson River Group, and notice of *Strotocrinus bloomfieldensis*." Journ. Cincinnati Soc. Nat. Hist., vol. iv., April, 1881, pl. 1, fig. 3, and pl. 4, fig. 4, pp. 71–73.

** Revision. II., p. 185.

be associated with the *Rhodocrinidæ* rather than with the *Actinocrinidæ* to some of which (*e.g.*, *Melocrinus*) it would be allied, owing to the presence of a tetramerous base. WACHSMUTH and SPRINGER point out that "no Actinocrinoid has ever been discovered in which the interradial field, except at the azygous side, extends to the basal disc." But MILLER'S description, which is borne out by his figures (one of which is reproduced in Plate 71, fig. 8), runs as follows: "The azygous area is remarkably large, and covered in the central part by a vertical series of plates having about the same size as the regular radial series, and upon each side of the vertical series there is a depressed area covered by small plates having a tubercle in the central part, as in the regular interradial areas. There are seven plates, each having a length about twice as great as its width, in the vertical series, from the basal plate upon which the series rests to the top of the vault. This vertical series is continued to the top of the proboscis, and contains in its entire length more than fourteen plates. It has such strong resemblance to the radial series, except as to the branching at the secondary radials, that the general appearance of the body is that of a species having six radial series."

There can, I think, be no reasonable doubt that the anal appendage of *Thaumatocrinus*, although free laterally, owing to the simplicity of the rays, is homologous with the vertical series of plates in the anal interradius of *Reteocrinus* and *Xenocrinus*; and it is not a little curious to find a character which died out some time before the Mesozoic epoch recurring in a recent *Comatula*. I am quite at a loss as to the probable function of this anal appendage in *Thaumatocrinus*, but it seems to differ from that of the Palæocrinoids in one point, for MILLER describes it in *Xenocrinus* as continued to the top of the proboscis, which is not the case in *Thaumatocrinus*. The lower part of the anal tube bears plates, but they are continuous with those covering the disc over which the anal appendage arches, without, however, forming any connexion with the plates in question.

It is difficult to consider the existence of interradials and of the anal appendage of *Thaumatocrinus* as instances of atavism, for no known Neocrinoid presents any similar characters, and it is a long way back from a recent *Comatula* to a Palæozoic Crinoid. The appendage soon disappeared, both the genera possessing it being of Lower Silurian age; but Crinoids with the interradials resting on the basals persisted into the Carboniferous period, and possibly also some with an anal appendage. Nothing of the kind is visible, however, in any genus of Neocrinoids, so that the reappearance of these characters in such a specialised type as a *Comatula* is not a little surprising. Associated with them we find the distinctly embryonic characters of persistent basal and oral plates, the latter occurring in no other *Comatula*, together with the simplicity of the undivided arms.

Thaumatocrinus is thus a type of unusual interest, and should be sought for carefully in any future deep-sea explorations. It is evident that the possibilities of the abyssal fauna are by no means exhausted yet.

The presence of the oral pyramid in *Thaumatocrinus*, as in *Hyocrinus*, suggests the

idea that the little specimen obtained from a depth of 2,325 fathoms, at Station 223 in the east Pacific, may, perhaps, be related to the former genus. Sir WYVILLE THOMSON* spoke of it as *Hyocrinus bethellianus* (?), with the remark, "It is certainly in many respects very unlike the adult *H. bethellianus*, but it may possibly turn out to be the young of that species." No figure of it is to be found either in the "Atlantic" or in any of the numerous plates which were drawn at Edinburgh under Sir WYVILLE'S direction, and it is to be feared that this "beautiful little thing" has been mislaid, as Mr. MURRAY has been unable to discover it among the material which was in Sir WYVILLE'S hands at the time of his death.

The discovery of *Thaumatocrinus* restores the numerical equality between the living genera of *Comatulæ* and of stalked Crinoids, and raises their joint total to twelve. Species of every genus, except *Holopus*, have been obtained by the various British expeditions for deep-sea exploration, as shown in the following table :—

Family.	Genera.	Number of species obtained.	Remarks.
Comatulidæ	*Antedon*, FREM.	83	Seven obtained by the "Porcupine" and the "Triton." The rest by the "Challenger."
	Actinometra, MÜLL.	52	"Challenger." One by the "Porcupine."
	Promachocrinus, P.H.C.	3	"
	Eudiocrinus, P.H.C.	3	"
	Atelecrinus, P.H.C.	2	"
	Thaumatocrinus, P.H.C.	1	"
Pentacrinidæ	*Pentacrinus*, MILLER	5	One obtained by the "Porcupine;" one species doubtful, perhaps representing a new genus.
	Metacrinus WY. TH., and P.H.C.	10	One founded on stem fragments only.
Bourgueticrinidæ	*Rhizocrinus*, SARS.	2	"Challenger" and "Porcupine."
	Bathycrinus, WY. TH.	3	One obtained by the "Porcupine."
Hyocrinidæ	*Hyocrinus*, WY. TH.	1	Besides one doubtful young specimen.

General considerations.

The peculiarities of *Reteocrinus*, as well as of *Thaumatocrinus*, have suggested certain morphological considerations bearing on the various classifications of the *Rhodocrinidæ* that have hitherto been proposed.

One cannot help wondering where the circular commissure of *Reteocrinus* was situated. In ordinary Crinoids with directly contiguous radials, each of them is traversed by a portion of the circular canal in which the commissure is lodged. But

* "Notice of New Living Crinoids belonging to the *Apiocrinidæ*." Journ. Linn. Soc. Zool., vol. xiii., p. 55.

in *Reteocrinus* and in *Xenocrinus* (Plate 71, fig. 8) the isolated radials are quite narrow, and the interradial spaces separating them are sometimes twice their breadth. How did the circular commissure traverse these spaces? Whether there were canals in the radials or not, the interradial portions of the commissures must have been freely exposed to the body-cavity at the bottom of the calyx, for it is not likely either that the commissure was absent, or that it was situated within the ring of basal plates. In this respect also, therefore, *Reteocrinus* presents an embryonic feature, for in the earlier stages of Pentacrinoid life the axial cords simply lie on the ventral surface of the radials and brachials, without having any channels hollowed out in these plates for their reception, as is subsequently the case; and whatever was the case with the radials and basals of *Reteocrinus*, it is improbable that the irregular interradial plates which were crossed by the cords were in any way grooved for their reception.* These may fairly be regarded as corresponding to the numerous irregular plates which occur upon the disc and between the rays of many Neocrinoids. Those of *Reteocrinus*, however, do not stop at the level of the second radials, but extend right down to meet the basals. Sometimes there appear to be only one or two between every two radials, *e.g.*, *R. gracilis*, but in other cases the number seems to be larger, and the plates can hardly be regarded as the complete morphological equivalents of the larger and more regular single interradials which occur in the *Rhodocrinidæ*.

The interradial portions of the circular commissure must have passed over the ventral surface of these large plates, if not actually piercing them. The same must be the case in *Thaumatocrinus*, and unless its radials are different from those of all other Neocrinoids, the axial cords must be lodged in canals, which is probably also true for the interradials. In any case, however, the relation of these plates to the axial cords shows that they belong, like the radials and basals, to the radial system, rather than to the perisomatic. It is not easy to make out their homologies in other Echinoderms, but they are perhaps represented in the disc of an Ophiurid by the proximal row of intermediate plates, while the interradials generally correspond to the distal rows.

The morphological differences involved in the separation or lateral union of the

* Müller, and more recently Zittel, have considered the presence or absence of canals within the calyx-plates as affording an important character which distinguishes the Palæozoic from the younger Crinoids. There are many Palæocrinoids, however, in which these canals are present, *e.g.*, *Allagecrinus*, *Platycrinus*, and all forms with true articular facets on the distal faces of the radials. *Platycrinus* has, nevertheless, been placed by Professor Chapman in his division *Emedullata*, the calyx and arm-plates of which are "without internal canals" (See "A Classification of Crinoids," read before the Royal Society of Canada, May 26, 1882). Strangely enough, *Marsupites* is placed in the same division, although any specimen with a good articular surface on the radials shows the opening of the central canal as distinctly as possible, and the canal actually pierces the substance of the plate, not ending abruptly on its ventral surface, as in the radials of *Cupressocrinus*.

(first) radials seem to have been first noticed by ZITTEL.* For he made them a fundamental distinction between the two families of *Glyptocrinidæ* and *Rhodocrinidæ*, in which he placed several genera that had been somewhat scattered in previous classifications. To the latter he referred types with a more or less depressed or spherical calyx, in which the lowest interradials rest directly on the basals, and form, together with the radials, a ring of ten alternating plates, *e.g.*, *Rhodocrinus* and *Ollacrinus*. In the *Glyptocrinidæ*, on the other hand, the calyx is higher, and the lowest interradials rest upon the upper edges of contiguous radials. This family includes *Glyptocrinus* and *Glyptaster* (HALL), with *Eucrinus* (ANGELIN), and also *Thylacocrinus* (OEHLERT), which seems somewhat out of place; for it has a large globular calyx, and five large interradials, which completely separate the radials from one another (Plate 71, fig. 7).

Messrs. WACHSMUTH and SPRINGER† express considerable doubt whether the differences between these two families in ZITTEL'S classification, "even if they were persistent, can be deemed sufficient for a family distinction. *Thysanocrinus* of the *Rhodocrinidæ* has generally at four sides the first interradial disposed between the first and second radials; while in *Thylacocrinus*, according to OEHLERT'S figure (Plate 71, fig. 7), all five first interradials rest directly upon the basals." I must confess that I cannot quite follow this argument. The *Thysanocrinus* referred to is HALL'S type of that name, which WACHSMUTH and SPRINGER subsequently place under *Dimerocrinus* (PHILLIPS); and in their generic diagnosis of it they say, "Interradial areæ composed of but few plates, the first one large, placed between the second radials, and leaning partly against the third, with two small plates above. Posterior, or anal area wider, the first plate in line with the first radials, and of the same size." *Thylacocrinus*, on the other hand, is said to have "Interradials numerous, the lower one resting directly on the basals;" *i.e.*, all five interradials meet the basals, and not that on the anal side only. This difference is further recognised by WACHSMUTH and SPRINGER, for they place the two genera in different sections of their family *Rhodocrinidæ;* and I do not, therefore, see the force of their doubts respecting the persistency of the characters in this portion of ZITTEL'S classification. In fact, they make great use of the position of the lowest interradials in defining their subdivisions of the family.

According to their general description of the *Rhodocrinidæ*, "In most of the genera the first interradial rests directly upon the truncate upper side of the basals, thereby separating the first radials all round. In others, however, only the first plate of the posterior or anal side is supported by a basal, that of the other four sides being placed against the upper corners of the first, and between the second radials, the former producing an almost pentahedral, the latter a more or less bilateral symmetry." This

* 'Palæontologie,' pp. 374–376.

† Revision. II., pp. 181, 182.

is perfectly true, and the distinction sharply marks off the section of bilateral *Glyptasterites* from the pentahedral *Rhodocrinites*.

The section *Glyptocrinites*, however, is somewhat heterogeneous. Its calyx is said to be almost perfectly pentahedral with the "interradial areas depressed, the first plate resting either directly upon the basals, or between the second and third radials, without special anal plate beneath their line." Only three genera are included in this section, and Messrs. WACHSMUTH and SPRINGER seem to have been somewhat uncertain about so grouping them; for they remark (p. 183), "It might have been not out of the way if we had placed the genus *Glyptocrinus* in a group by itself, as it differs from *Archæocrinus* and *Reteocrinus*, with which it has been associated, *and from all other Rhodocrinidæ*,* in having the first plate at each interradial side placed between the second radials."

In *Archæocrinus* (W. and S.), on the other hand, the lowest interradials rest directly upon the basals, as is also the case with the small and irregular interradials of *Reteocrinus*. Both these genera, therefore, have isolated radials and a pentahedral symmetry ("somewhat bilateral" in *Reteocrinus*) just as in the *Rhodocrinites*. But the latter lack the "rounded strongly elevated ridges" which distinguish the radials of *Archæocrinus* and *Reteocrinus*. This, however, is merely a character in the superficial ornamentation of the calyx; and it seems to me of altogether minor importance as compared with the morphological differences between the lateral union and the isolation of the radials. In this last feature *Archæocrinus* and *Reteocrinus* resemble the *Rhodocrinites*, and if the limits of that section could not be enlarged to receive them, they might very well be left in a group by themselves, distinguished by their ornamentation.

But they are out of place by the side of *Glyptocrinus*, with *all* its radials united laterally. It thus represents a comparatively late ontogenetic condition, not even the radials of the posterior side being separated by an anal plate as in the *Glyptasterites*. There are, doubtless, close affinities and remarkable transition forms between *Glyptocrinus* and *Reteocrinus*, as asserted by Messrs. WACHSMUTH and SPRINGER. But these depend very largely upon the characters of the rays and arms, which are of a comparatively subordinate value; while the lateral separation of the radials in the last named genus, and in the *Rhodocrinites*, is a fact of considerable importance in Crinoid Morphology.

It must be remembered also that *Glyptocrinus* has decided affinities with some of the earlier *Actinocrinidæ*, certain species appearing to be without under-basals. In fact, according to the American authors, "It is a question whether that genus, at least partly, should not be arranged with the other group altogether."

Thus, then, I would divide the *Rhodocrinidæ* (W. and S.) into groups as follows:—

* The italics are mine.

I. Radials completely separated laterally, either by single interradial plates, or by groups of small ones.
   - α. No ridges on the radials . . . . . *Rhodocrinites* (W. and S.)
   - β. With ridges on the radials . . . . . *Archæocrinus.* / *Reteocrinus.*

II. The two posterior radials separated by an anal plate which rests on a basal . . . . . *Glyptasterites* (W. and S.)

III. Radials in contact all round the calyx . . . . . *Glyptocrinus.*

I cannot help suspecting, however, that ZITTEL's arrangement of these genera into two families, *Glyptocrinidæ* and *Rhodocrinidæ*, is the most natural one; though I should place *Thylacocrinus* in the latter, and not in the former as he has done.

POSTSCRIPT.

(Added February 1, 1884.)

During the past year the peculiarities of *Thaumatocrinus* have naturally been much in my mind, and I have been led to believe that the structure which I have called the anal appendage is represented in other Palæocrinoids besides the two Silurian genera already mentioned.

WACHSMUTH and SPRINGER* describe *Taxocrinus* and *Onychocrinus* as having a small lateral proboscis in the anal area, which consists of a series of from two to six narrow quadrangular plates, longitudinally arranged, and resting on the upper surface of a basal. MEEK and WORTHEN† spoke of it in *Onychocrinus* as "really looking very much like a diminutive arm rising from the anal area;" and they subsequently found the remainder of the anal interradius to be occupied by a great number of minute irregular plates, which pass gradually upwards into those of the "vault," just as in *Reteocrinus* and *Xenocrinus*. If *Thaumatocrinus* were a larger type, with plated perisome between the rays, as in *Pentacrinus asteria*, its tapering anal appendage would be in the same condition as that of *Onychocrinus*, becoming merged above into the general plating of the anal interradius.

I do not think, therefore, that WACHSMUTH and SPRINGER are quite correct in describing *Taxocrinus* and *Onychocrinus* as having "a small lateral tube." That the arm-like series of plates supported the lower portion of the anal interradius is doubtless true. But I do not imagine the plates to have been in any way hollowed on their inner sides for the reception of the hind-gut. This undoubtedly opened to the exterior at a higher level, through a regular anal tube just as in other Crinoids.

* Revision. I., pp. 46–53.

† 'Palæontology of Illinois,' vol. ii., p. 243; vol. iii., p. 494.

Excellent figures of the anal series in *Taxocrinus* are given by SCHULTZE* and ANGELIN,† while that of *Onychocrinus* is well represented by MEEK and WORTHEN.‡ These figures may be advantageously compared with those of *Thaumatocrinus* on Plate 71.

Since the preceding paper was presented to the Society in April, 1883, the discussion between Messrs. MILLER and WACHSMUTH respecting the nature of *Reteocrinus* has been carried on with considerable vigour.

Stimulated by MILLER'S criticisms, Messrs. WACHSMUTH and SPRINGER were able (with the help of Mr. W. R. BILLINGS) to demonstrate a considerable amount of resemblance between *Reteocrinus stellaris* (BILLINGS), and *Glyptocrinus nealli* (HALL). Both types have (1) the under-basals visible externally, (2) the radials separated laterally by the lowest interradials, which rest on the basals, and (3) a prominent median row of plates in the anal interradius; though WACHSMUTH and SPRINGER do not lay much stress upon the last point. "*Reteocrinus* is readily identified by its highly elevated radial ridges, and depressed interradial spaces, filled with numerous small plates of irregular arrangement, and extending between the first radials down to the basals; by its under-basals, often well developed; its strongly marked bilateral symmetry; and by its ten primary arms as a rule."§

MILLER replied by giving a detailed comparison of *Glyptocrinus nealli* and *Reteocrinus stellaris*, and believed himself to have found such great differences between them, "that it is doubtful whether they should even be classified in the same family."‖ He lays much stress upon differences in the general aspect of the cup and arms; a little more so, perhaps, than is necessary, considering the poor state of preservation of the Canadian specimens. Two points, however, seem to me to be of greater importance. In all the species which have been lately referred to *Reteocrinus* by WACHSMUTH and SPRINGER, the under-basals are poorly developed, or perhaps even absent; while the third radial is the axillary. But in *R. stellaris* there are quite large under-basals, and the fourth radial is the axillary; and I have some doubt, therefore, as to the advisability of referring to this little-known generic type a number of species which do not present these characters, more especially the latter one. They all agree, however, with *Reteocrinus stellaris* in a feature which both WACHSMUTH and SPRINGER and I myself regard as specially distinguishing *Reteocrinus* from *Glyptocrinus*, viz.,

* "Monographie der Echinodermen des Eiflerkalkes." Denkschr. d. Wiener Akad. Bd. xxvi., 1866. Taf. iv., figs. 2, 2*b*, 3, 4*b*.

† "Iconographia Crinoideorum," &c. Stockholm, 1878. Tab. xviii., fig. 8. Tab. xx., figs. 9, 13, 16. Tab. xxiii., fig. 5.

‡ 'Palæontology of Illinois,' vol. v., pl. xiv., fig. 4.

§ "Remarks on *Glyptocrinus* and *Reteocrinus*, two genera of Silurian Crinoids." Amer. Journ. Sci., vol. xxv., April, 1883, pp. 265-266.

‖ "Response to the Remarks of Messrs. WACHSMUTH and SPRINGER on the genera *Glyptocrinus* and *Reteocrinus*." Amer. Journ. Sci., August, 1883, p. 112.

the separation of the first radials by the calyx-interradials. WALCOTT* has recently pointed out that a new species, which he has described as possessing this character, "departs from the typical form of *Glyptocrinus*," and he suggests its reference to another generic type. MILLER, however, regards this striking difference in the position of the lowest interradial as of no systematic value whatever, even for specific classification. For he identifies *Reteocrinus gracilis* (WETHERBY), with a type previously described by himself as *Glyptocrinus angularis*, and since recognised by WACHSMUTH as a true *Glyptocrinus*. The lowest interradials rest "between the upper sloping sides of the first radials;" while in *R. gracilis* the radials are widely separated laterally, and the lowest plates of the irregular interradial series rest upon the basals. This feature also occurs in four species which are referred by MILLER† to *Glyptocrinus*, although in *G. decadactylus*, which he takes as his type, "the regular interradial areas have one plate resting upon the primary radials!"

But MILLER goes even further than this. He establishes a new genus, *Gaurocrinus*, for types hitherto described under *Glyptocrinus*, but possessing a dicyclic base; and he refers to it five species, two of which are new. In one of these, and in the three species previously known, the lowest interradials rest upon the basals. But in *Gaurocrinus splendens*, n.sp., the large hexagonal basals are "not truncated upon the upper face by an interradial." MILLER'S mode of classification, therefore, totally disregards such important morphological differences as the separation or lateral union of the primary radials; and I cannot believe that it will find acceptance among philosophical palæontologists.

Gaurocrinus differs from *Glyptocrinus* in having a dicyclic base,‡ that of *Glyptocrinus*

* "Descriptions of new species of Fossils, from the Trenton Group of New York." 35th Ann. Report N. Y. State Mus. Nat. Hist., p. 2 (of separate copy).

† "*Glyptocrinus* redefined and restricted, *Gaurocrinus Pycnocrinus*, and *Compsocrinus* established." Journ. Cincinn. Soc. Nat. Hist., Dec., 1883, vol. vi., pp. 217-228.

‡ It is much to be regretted that Mr. MILLER still uses the empirical and utterly irrational nomenclature, which is now being gradually replaced by a system based upon sound morphological considerations. He remarks that "the policy of changing the nomenclature may well be doubted, and ought not to be entered upon without the clearest conviction that, by so doing, error of some kind is being eradicated." No better illustration of such an error could be found than his statement that *Gaurocrinus* "is primarily distinguished from *Glyptocrinus* by possessing five sub-radials." This name was given by DE KONINCK to the so-called parabasals of MÜLLER, "afin de faire comprendre qu'ils alternent avec les radiales;" and since "the presence or absence of sub-radial plates is regarded of special generic importance" by Mr. MILLER, we are led to conclude that the "basals" of *Glyptocrinus* (MILLER), in which sub-radials are absent, do *not* alternate with the radials. But this is exactly contrary to the fact! Sub-radial plates, alternating with the radials, *are invariably present;* and it is the radially situated under-basals which may be "present or absent." In the former case Mr. MILLER calls them basals, which name he also gives to the sub-radial plates when there are no under-basals.

This method is doubtless both "easy" and "expressive." But it unfortunately implies an homology between the radially situated plates of one genus (*e.g.*, *Poteriocrinus*), and plates which are interradial in another (*e.g.*, *Platycrinus*); and this is utterly opposed to the fundamental principles of morphology, not only in the Crinoids, but also in the Echinoderms generally.

being monocyclic only. It is curious, however, that MILLER should make *Glyptocrinus decadactylus* the type of a genus, the speciality of which is the presence of a monocyclic base. For HALL, MEEK, and WACHSMUTH* have all described it as being dicyclic, *i.e.*, as possessing under-basals.

It has been abundantly proved within the last few years that the presence or absence of under-basals upon the exterior of the calyx is a character which is generally of very little value for systematic purposes. *Encrinus* and *Heterocrinus* afford good instances of this. The late Mr. MEEK, whose judgment Mr. MILLER will hardly question, was fully aware of the great amount of variation in the cup of *Heterocrinus*, some species having one series of plates beneath the radials, and others, two; while he further recognised that the upper row of the dicyclic base represents the single row of the monocyclic forms.

The same is the case with *Glyptocrinus* and its allies, as was recognised by WACHSMUTH and SPRINGER, though MILLER will not admit it. One would like to know whether he would rearrange the species of *Heterocrinus* on the principles which have led him to separate *Gaurocrinus* from *Glyptocrinus*.

DESCRIPTION OF THE FIGURES.

PLATE 71.

The following lettering is used throughout all the figures:—*aa*, anal appendage; *an*, anambulacral plates; *at*, anal tube; *b*, basals; b_2, second brachial; *c*, cirrus; *cd*, centrodorsal; *i*, interradial plates; *o*, orals; *r*, radials.

Figs. 1–5.—*Thaumatocrinus renovatus*. All × 15.

Figs. 1 and 2. Side views, radial. In 1, the right anterior, and in 2, the right posterior ray faces the observer.

Figs. 3 and 4. Side views, interradial. Fig. 3 shows the left anterior interradius with its single large interradial (*i*) and anambulacral plates (*an*).

Fig. 4 shows the posterior or anal interradius, in which the interradial plate bears the jointed anal appendage (*aa*).

Fig. 5. View of the disc from above, showing the anal tube and appendage, the oral pyramid, and the marginal zone of anambulacral plates.

Fig. 6. Radial view of an *Antedon*-Pentacrinoid from S. 344, showing the lateral union of the radials. × 15.

Fig. 7. Calyx of *Thylacocrinus;* after OEHLERT.

Fig. 8. Anal side of *Xenocrinus penicillus*, showing the anal appendage (*aa*); after MILLER.

* Revision. II., p. 7.

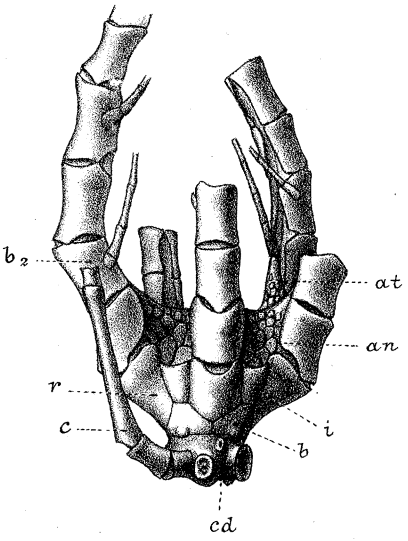

Fig. 1.

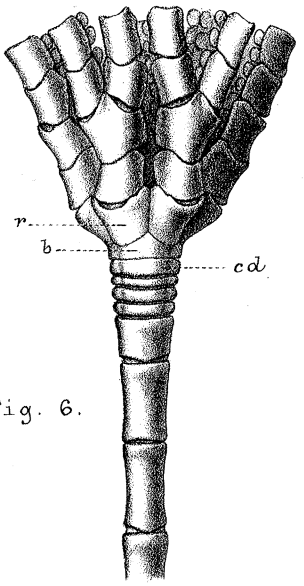

Fig. 6.

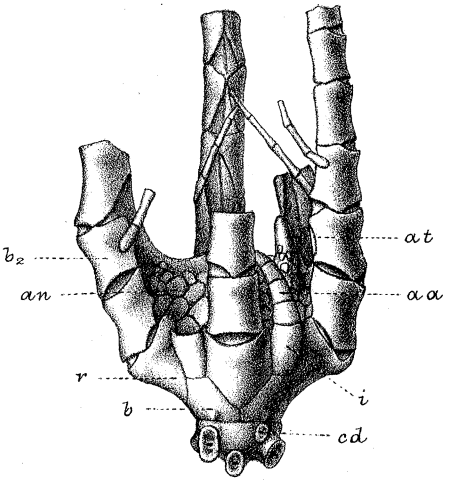

Fig. 2.

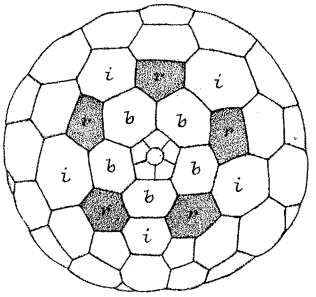

Fig. 7.

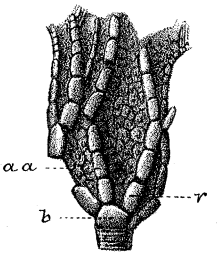

Fig. 8.

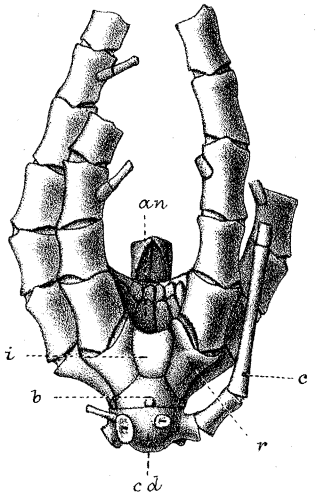

Fig. 3.

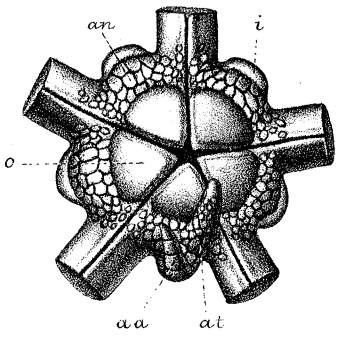

Fig. 5.

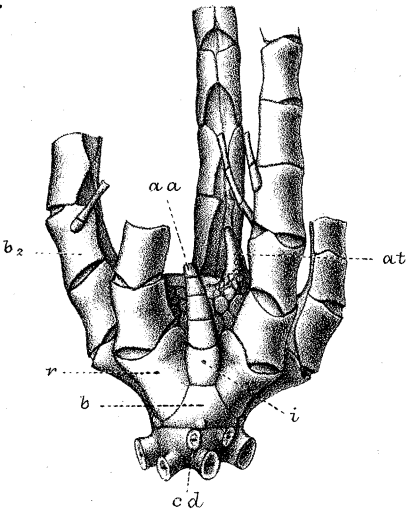

Fig. 4.

Berjeau & Highley del. et lith. West, Newman & Co lith.

THAUMATOCRINUS RENOVATUS, Nov. gen. et sp.