The addition of this genus to the Dendrocrinites suggests that, after all, *Thenarocrinus*, to which it is so closely allied, may find more fitting companionship with that family-party than with the somewhat peculiar *Carabocrinus*. The latter is in truth a crabbed unsociable animal, whose nature, through the kindness of my Canadian friends, is now becoming better known to me.

EXPLANATION OF PLATE XII.

Mastigocrinus loreus, gen. et sp. nov.

Fig. 1. The smaller specimen in the Dudley Museum.
Fig. 2. 133 Mason College.
Fig. 3. 57048 B.M. (See p. 195.)

From a photograph of the specimens, about $2\frac{1}{6}$ larger than nature.

XXXII.—*British Fossil Crinoids.*—VIII. Cyathocrinus: C. acinotubus, *Ang.*, *and* C. vallatus, *sp. nov.*, *Wenlock Limestone.*

By F. A. Bather, M.A., F.G.S.

[Plate XIII.]

Historical Introduction.

The name *Cyathocrinus*, or, as it used to be written, *Cyathocrinites*, was first used by J. S. Miller in 1821 on page 85 of his 'Natural History of the Crinoidea,' and is derived from κύαθος, a cup; it has also been used by all subsequent writers on the subject. When, however, we enquire what particular form of Crinoid should be denoted by this name, we are speedily involved in difficulties. Fortunately Messrs. Wachsmuth and Springer, in their 'Revision of the Palæocrinoidea' (I. 79; Proc. 1879, p. 302), have dealt fully with this subject, and their conclusions accord with common sense and with the rules of nomenclature. There are only a few points in which insufficient acquaintance with European material or European literature has led them astray. Since their work is, or should be, in the hands of every serious student of the Crinoids, a short explanation of the position adopted is all that is here required.

The four species referred by Miller to *Cyathocrinus* belong to four different genera, not to mention families and suborders. The first of these, *C. planus*, should of course be taken as the type: the others are now known as *Taxocrinus tuberculatus*, *Crotalocrinus rugosus* (= *C. verrucosus*, Schloth., sp.), and *Parisocrinus quinquangularis*.

As to *C. planus* itself a little difficulty has arisen. Miller's

diagnosis of the genus (p. 85) is as follows :—"A Crinoidal animal, with a round or pentagonal column formed of numerous joints, having side arms proceeding irregularly from it. On the summit adheres a saucer-shaped pelvis of five pieces, on which are placed in successive series, five costal plates, five scapulæ, and an intervening plate. From each scapula proceeds one arm having two hands." The generic diagram facing p. 85 shows five pentagonal infrabasals, five basals, of which four are hexagonal (or pentagonal according to the angles formed by the upper sides of the infrabasals) and the fifth heptagonal (or hexagonal), five radials with a deep notch and an articular facet about one third the width of the plate, and a hexagonal anal *x* in line with the radials. The figures of *C. planus*—1, 2, 3, 4, 5, 6, 7, 8, 9, 29, 30—show that this diagram was taken from that species, and bear out the diagnosis so far as the cup is concerned. Fig. 1, however, shows dichotomous pinnulate arms, and we know of no genus with arms of this character that has a dorsal cup like that shown in the diagram. The Austins' explanation of this was a probable one. They said (Monogr. Rec. & Foss. Crinoidea, p. 61), "Miller's principal figure of this species cannot be depended on, as he appears to have taken the rays of the *Taxocrinus longidactylus* and placed them on the body of the *C. planus*." On this Wachsmuth and Springer remarked (Revision, I. 81, footnote 2), "In supposing these to be the arms of *Taxocrinus*, Austin is certainly mistaken." Austin, however, applied the name *Taxocrinus longidactylus* to a specimen from the Carboniferous Limestone, near Walton Castle in Clevedon Bay, of which a figure had been published by George Cumberland *. This very figure was referred by Miller (p. 86) to *C. planus*, and it is quite likely that the arms of his own fig. 1 were suggested by it. As a matter of fact there can be little doubt that Cumberland's figure represents a *Scaphiocrinus* with two primibrachs, although the pinnules are merely indicated in his drawing by rough shading. The same specimen was figured by Austin, pl. xi. fig. 3 *a*, under the name *Poteriocrinus longidactylus* (p. 88), thus showing that the name *Taxocrinus* was inserted by mistake on p. 61. Mr. W. P. Sladen, in his revision of the "Genus *Poteriocrinus* and allied forms" †, left this species out in the cold; but Messrs. Wachsmuth and Springer referred it

* "Description of some new Fossil Encrini and Pentacrini, lately discovered in the neighbourhood of Bristol," Trans. Geol. Soc. 1st ser. vol. v. part 1, pp. 87–94, with pls. ii.–v.: London, 1819. See pl. iii. fig. 1.

† Proc. West Riding Yorksh. Geol. and Polyt. Soc. vol. vi. (n. s., vol. i.) part iv. pp. 242–253, pl. x. (1877), 1878.

to *Scaphiocrinus* (Rev. I. 114, Proc. 1879, p. 337). Miller's fig. 28 probably represents a *Scytalecrinus*, but the anal area is not very clear; at any rate it does not agree with the diagnosis or diagrams of *Cyathocrinus*. In his diagnosis of the genus Miller stated that the stem had irregular "side arms" or cirri, and such were represented in his figures 26 and 27; but of these the Austins said (*op. cit.* p. 61), they "are not the side arms of any species of *Cyathocrinus*, 26, being a small column, and 27, the column and side arms of a *Poteriocrinus*." No species agreeing in other respects with Miller's diagnosis is known to possess cirri of this nature.

The foregoing specimens were no doubt placed, as was the rest of J. S. Miller's valuable collection, in the Bristol Museum*, where they were shown to L. Agassiz by the then curator, Mr. S. Stutchbury †. But, to the disgrace of the inhabitants of that town, all these treasures have been gradually allowed to disappear from that, their natural resting-place.

There was, however, another specimen figured by Miller (figs. 29 and 30), which was said by him (p. 87) to be "in the Ashmolean Museum at Oxford." The drawings agree perfectly with the generic diagnosis and diagram, and this specimen would be the best to take as the type of the species. Unfortunately, in the transfer from the Ashmolean to the new Museum at Oxford, this, with other important specimens, appears to have been mislaid, and all search for it has up till now been fruitless. It were to be wished that those in charge of some of our museums would remember that they are responsible, not merely to their immediate employers, not to the town, nor even to the nation, but to the whole world now and to come.

J. Phillips, in his 'Geology of Yorkshire' (1836), did not rocognize *C. planus*. He figured, however, under the name *C. distortus* (vol. ii. p. 206, pl. iii. fig. 34), a specimen that was obviously of the same species as Miller's figs. 29 and 30. The Austins appear to have studied Miller's type specimens before they were 'conveyed' from the Museum of the Bristol Institution, and they retained the species *C. planus*, figuring (*op. cit.* pl. vii. fig. 4 *c*, *d*) a specimen which was in all probability the original of the cup in Miller's fig. 1, as well as a specimen (pl. vii. fig. 4 *e*) probably the same as that figured by Phillips for *C. distortus*, which species they con-

* See 'The West of England Journ. Sci. and Lit.,' no. 1, pp. 4, 19, 98, and 252 : Bristol, Jan. 1835.

† L. Agassiz, 'Poissons Fossiles,' 4e livr., feuilleton additionel, p. 52 (1835).

sidered as a synonym of *C. planus*. There is therefore no difficulty in deciding what Miller meant by *C. planus*, and there should consequently be no difficulty in distinguishing the genus *Cyathocrinus*.

Before leaving *C. planus*, however, it may be as well to correct a few mistakes made by the earlier writers, lest they should again prove cause of confusion.

Miller's erroneous ascription of cirri to the species has already been noted. With regard to the arms Miller wrote (p. 87), "they are all tentaculated at alternate sides, and resemble those of Pentacrinus Caput Medusæ." Similarly the Austins, though they scouted Miller's figure of the arms, remarked (p. 60), "The rays were no doubt tentaculated, although none of the specimens show the tentacula." It is certain, however, that tentacula or pinnules are not present in this species.

The Ashmolean specimen figured by Miller showed the base of the anal tube clearly; Miller, however, merely said (p. 87), "this [abdominal] integument is swollen out, and gives the specimen a singular appearance." The Austins regarded this aperture as the mouth. De Koninck and Le Hon* appear to have understood that it was connected with the anus; but neither they nor previous writers were aware that the opening was followed by an anal tube. The plates around the base of this tube were displayed by Miller in his dissected diagram, fig. 30. Wachsmuth and Springer, however (Rev. I. 81, footnote 1) consider that "the four small plates, arranged in the figure in a half circle, are to represent the interradials (oral plates) [deltoids] in the dome, and not the plates of the ventral sac, as might be expected." This cannot be right: the specimen, as proved by fig. 29, possessed no deltoids, while in both figures the letter T points to a larger and irregularly shaped plate which was most probably the madreporite.

Miller distinctly (p. 87), and the Austins in more ambiguous language (p. 59), both stated that the articular facet of the radial was perforated. To the question whether there are any species of *Cyathocrinus* that possess this character we shall recur later on; in the Carboniferous species *C. planus*, at any rate, there is no doubt that in the radial facet the axial canal is not separated from the ventral groove.

* 'Recherches sur les Crinoïdes du Terrain Carbonifère de la Belgique,' Mém. Acad. Roy. Belgique, vol. xxviii. p. 81: Brussels, 1854.

Restriction of the Genus.

Having determined the type species of the genus, we have now to consider various forms that have at different times been confused with *Cyathocrinus*.

It is unnecessary to say more about the separation of *Poteriocrinus* from *Cyathocrinus*, since it differs not only in the anal area but in the possession of pinnules.

Parisocrinus has arms like *Cyathocrinus*, but an anal area like *Poteriocrinus*; hence there is no real reason for confusing the two as has often been done.

J. Hall * extended the diagnosis of *Cyathocrinus* to include forms with a small quadrangular radianal. These forms, however, differ in other respects, besides the presence of a radianal, from *Cyathocrinus*, and doubtless belong to quite a different family—the Decadocrinidæ. In America such forms are represented by *Barycrinus* and *Vasocrinus*: in England it is the Silurian *Botryocrinus* that has been labelled *Cyathocrinus* †; while a Carboniferous fossil that is probably a *Barycrinus* appears to have been considered a *Poteriocrinus*.

De Koninck and Le Hon ‡ gave a diagram of *Cyathocrinus* in which the anal *x* was represented as pentagonal and as supporting two small hexagonal plates. This was probably a mere slip, for neither in *C. planus* nor in *C. mammillaris*, the only species described by them, has the anal *x* that shape. Some specimens of *C. multibrachiatus* from the Keokuk group of North America, that are in the British Museum, appear to have an anal *x* of this shape, but it is not typical of the genus. In fact the diagram given by De Koninck and Le Hon resembles, in this respect at least, that of *Ottawacrinus* alone among the Inadunata. They also give, under the head of *Cyathocrinus*, a diagram of the anal area of a Permian species, of which all we can say is that it certainly is not a *Cyathocrinus*.

The Austins (*op. cit.* p. 66), in reviewing the species ascribed by different authors to this genus, said, "Not one of the so-called *Cyathocrini* of Murchison's Silurian System properly belong to the genus." This is perfectly true: it has long been known that *C. tuberculatus* is a *Taxocrinus*, that *C. pyriformis* (*sic*) is an *Ichthyocrinus*, and that *C. rugosus* is a *Crotalocrinus*; in fact these corrections were made when the plates were reprinted to illustrate Murchison's

* Rep. Geol. Surv. Iowa, vol. i. part ii. p. 622 (1858).

† "Brit. Foss. Crin., V.," Ann. & Mag. Nat. Hist. ser. 6, vol. vii. p. 395, May 1891; and VI., p. 189, *anteà*.

‡ 'Recherches sur les Crinoïdes &c.,' pp. 79 *et sqq.* (1854).

'Siluria' (edit. 3, 1859). The names *Cyathocrinus goniodactylus*, *C. arthriticus*, and *C. capillaris*, of 'The Silurian System' and 'Siluria,' have had a longer existence; indeed it was not till 1878, when Angelin founded *Gissocrinus*, that there was any genus for the reception of those species. They, however, together with various species to which J. W. Salter gave the Catalogue names of *C. scoparius*, *C. squamiferus*, *C.* sp. 1, and *C.* sp. 5, all appear to differ from *Cyathocrinus* in the possession of three infrabasals instead of five, and must therefore be referred to *Gissocrinus*.

Wachsmuth and Springer (Rev. I. 83, Proc. 1879, p. 306) said, "*Palæocrinus* Billings is not distinct from *Cyathocrinus*. The construction of the calyx is identical." E. Billings founded *Palæocrinus* in 'Figures and Descriptions of Canadian Organic Remains,' decade iv. (1859), on p. 24, the type species being *P. striatus* (p. 25); he also referred to the genus *P. angulatus* (p. 45), *P. rhombiferus* (p. 45), and *P. pulchellus* (p. 46). Wachsmuth and Springer (Rev. III. 225; Proc. 1886, p. 149), after examining the type specimens, entirely changed their views with regard to *Palæocrinus*. They said, "The specimen of *P. striatus*, upon which the genus was proposed, is very imperfect, and may be a *Carabocrinus*, *Dendrocrinus*, or a new genus." *P. angulatus* was referred by them, without any doubt, to *Dendrocrinus*. Through the kindness of Dr. A. R. C. Selwyn and Mr. J. F. Whiteaves, the type specimens of Billings's four species, which are the only specimens known, are now before me. As regards *Palæocrinus striatus*, there is no doubt that it is not a *Cyathocrinus*; but a very careful examination has convinced me that neither is it a *Carabocrinus* or a *Dendrocrinus*. I should not, however, like to say whether it can really be regarded as an independent genus. *P. angulatus* also is no *Cyathocrinus*; but I quite fail to see why it should be referred to *Dendrocrinus*: the radianal is small, apparently four-sided, and occupies a position more like that in *Botryocrinus* than that in any other Inadunate genus. The specimens of *P. rhombiferus* and *P. pulchellus* do not show the anal area; for the present therefore the reticence of Messrs. Wachsmuth and Springer concerning them is the best example to follow.

Among the genera that have been confused with *Cyathocrinus* there only remains one worthy of discussion, namely the genus *Sphærocrinus*; and the history of this is somewhat peculiar. The only species of the genus is *S. geometricus*, a fairly well-known form from the Devonian rocks of both Germany and England. The species was founded by Gold-

fuss † and was referred by him to *Cyathocrinus*. Since the diagnosis of that genus given by Goldfuss was simply a translation of Miller's, it follows that *C. geometricus* was regarded by its author as possessing but one plate in the anal area. Neither the figures of Goldfuss nor that given by J. Phillips in his 'Palæozoic Fossils of Cornwall &c.,' pl. lx. fig. 41* (1841), show the anal plates. The Austins, in their Monograph, p. 61 (1845), likewise referred this species to *Cyathocrinus*, speaking as though there were one anal plate only, placed as in *Cyathocrinus*; in fact the diagram of *Cyathocrinus* on p. 58 is said to be taken from *C. geometricus*. C. F. Rœmer ‡ appears to have found Miller's description of *Cyathocrinus planus* quite unintelligible, and consequently proposed to take Miller's second species, now known as *Taxocrinus tuberculatus*, as the type of *Cyathocrinus*, while he made *C. geometricus* the type of a new genus, *Sphærocrinus*. From his diagnosis of *Sphærocrinus* we learn that he supposed the genus to have only three infrabasals, while he again mentions, though with some doubt, the single anal plate. Rœmer's view was adopted by G. and F. Sandberger in 'Die Versteinerungen des Rheinischen Schichtensystems in Nassau,' pp. 389, 390 (Wiesbaden, 1850–1856). Joh. Müller § was the first to point out the correct structure of *C. geometricus*, describing a new variety of it, or possibly, as he regarded it, a closely allied species, under the name *Poteriocrinus hemisphæricus*. He showed that there were five infrabasals, and that the anal area possessed a radianal, an anal *x*, and another small plate (*rt*) on the right of anal *x*, resting on the radianal. L. Schultze ‖ placed all varieties of this species under the one head *Poteriocrinus geometricus*, and gave figures (Taf. v. figs. 6 *d*, 6 *f*) entirely confirming Müller's description and figures of the anal area. It is odd that Messrs. Wachsmuth and Springer, who refer to both Müller and Schultze, should still have kept this species under *Cyathocrinus* in the first part of their Revision, saying (p. 83), "it has all the characters of *Cyathocrinus*, not only in the construction of the calyx, but also of the vault." In 1886, however (Rev. III. 226; Proc. p. 150), they were inclined to

† 'Petrefacta Germaniæ,' vol. i. part 3, p. 189, tab. lviii. figs. 5 *a*, *b* (1831).

‡ "Beiträge zur Kenntniss der fossilen Fauna des Devonischen Gebirges am Rhein," Verhandl. d. naturhist. Ver. d. preuss. Rheinlande, 8th Jahrg. pp. 363–369: Bonn, 1851.

§ "Ueber neue Echinodermen des Eifeler Kalkes," Abhandl. k. Ak. Wiss. Berlin, Jahrg. 1856, p. 250, Taf. ii. figs. 4, 5, 6, 7 (1857).

‖ "Monographie der Echinodermen des Eifler Kalkes," Denkschr. k. Ak. Wiss. math.-nat. Cl. Bd. xxvi. (1866) p. 51; Wien, 1867.

separate *Sphærocrinus* from *Cyathocrinus*; still this was not on account of any differences in the structure of the cup, but merely because the axial canal in the radials was separated by stereom from the ventral groove. To the question whether this character is of generic importance we shall return immediately; for the present it is enough to state that the description of *Poteriocrinus geometricus* given by Müller and Schultze is proved correct by a large number of specimens in the British Museum. So long as the arms of this species are unknown one cannot definitely say to which genus it belongs; it would probably be safer to place it in *Parisocrinus*, but we may be quite certain that it has nothing to do with *Cyathocrinus*.

A single species, hitherto undescribed, which may be regarded by many as a *Cyathocrinus*, has been separated therefrom and made the type of a new genus, under the name *Mastigocrinus loreus*. The reasons for this have been so fully given in the preceding paper (*anteà*, p. 200) that it would be waste of space to repeat them here. Suffice it to say that no *Cyathocrinus* has yet been found with a ventral sac, a tegmen or a stem like those of *Mastigocrinus*.

Wachsmuth and Springer (Rev. III. 326; Proc. 1886, p. 150) have stated that the possession of a separate axial canal by the radials is a structure that "occurs exclusively in species from the Silurian and Upper Devonian, never in the Carboniferous, neither in *Cyathocrinus* nor other genera." "Whether," they continue, "all species of *Cyathocrinus* from Gothland and Dudley possess this structure, cannot be ascertained from the figures, but if they do, it may form the basis of a separation which seems to us very desirable." Now, even if we were safe in accepting this remarkably broad and dogmatic, though not very clear, statement, intermediate forms might still occur in the Lower and Middle Devonian. Even if they did not, so small a point would hardly be enough to differentiate two genera; for it is no rare thing to find the axial canal separate in one species of a genus, in one individual of a species, or in the earlier brachials of an individual, while it is merely a tongue from the ventral groove in others *. Moreover there do not appear to be any other constant or decided differences between the Carboniferous species of *Cyathocrinus* and such typical Silurian species as *C. acinotubus*, *C. ramosus*, and *C. visbycensis*. As a matter of fact, however, even this difference does not exist, for the axial canal is not separate in the Silurian *C. vallatus*, although

* See "Brit. Foss. Crin.—V. *Botryocrinus*," Ann. & Mag. Nat. Hist. ser. 6, vol. vii. p. 392, May 1891.

it is separate in the closely allied *C. acinotubus*; while it is separate in some individuals of *C. striolatus* from Gotland but not in others. Consequently it seems advisable for the present to retain both Silurian and Carboniferous species in one genus—*Cyathocrinus*—with the following

Generic Diagnosis.

IBB 5, equal, pentagonal. BB 5, hexagonal except post. B, which is heptagonal and supports *x*. RR 5, shield-shaped, with facet circular or elliptical in outline, and occupying from less than $\frac{1}{3}$ to $\frac{2}{3}$ width of R. *x* tetragonal to hexagonal, in line with RR, and about $\frac{2}{3}$ width of R. Arms long, simple, dichotomizing regularly several times; covering-plates alternating, in from 1 to 4 (or 5 ?) rows on either side. Ventral sac composed of usually hexagonal plates, either smooth or slightly folded. Tegmen consolidated by deltoids. Madreporite distinct.

Description of the Genus.

Dorsal Cup cyathiform; with sides convex, straight or convexo-concave; with plates plane or tumid; surface smooth, shagreened, or slightly ridged either radiately or concentrically. No pronounced axial folding.

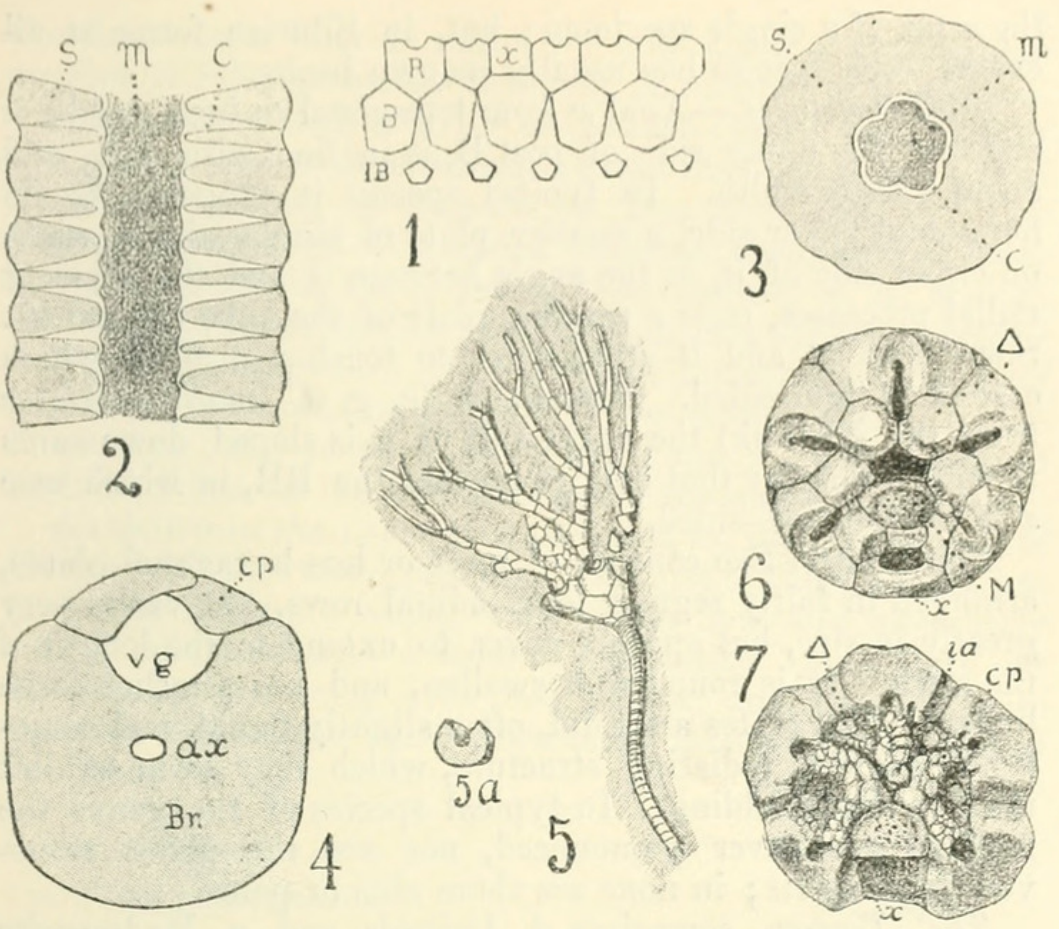
IBB 5; pentagonal; lying at very various angles to stem, and varying very greatly in height.

BB 5; hexagonal, except post.B, which is heptagonal. These also vary much in their proportions, but are usually large.

RR 5; of normal outline; as large as or larger than BB. Articular facet from a little less than $\frac{1}{3}$ to $\frac{2}{3}$ width of plate, usually about $\frac{1}{2}$; circular or elliptical in outline; directed outwards and upwards at very various angles; axial canal may or may not be separated from the ventral groove by stereom. Radial processes curve upwards and inwards to the deltoids.

Arms non-pinnulate, dichotomous; usually long and branching from 5 to 7 times (in Silurian species at least); with more ossicles in each series towards the inner side of each dichotom. Rather stout, not tapering much, and with short ossicles (in Silurian species); or fine, tapering, with long ossicles (in Carboniferous species). Covering-plates well developed; either as solid, alternating series, or in rows of 2 to 5 (?) deep on either side of ventral groove.

I Br from 1 to about 8: the number often varies greatly in



DRAWINGS TO ILLUSTRATE THE MORPHOLOGY OF *CYATHOCRINUS.*

1. The dissected cup; with the anterior radius on the right.
2. Longitudinal median section through ten columnals of *C. acinotubus.* *s*, stereom of ossicle; *m*, matrix filling axial canal; *c*, calcite taking the place of former ligament.
3. Transverse section through the stem of *C. acinotubus.* Lettering as above. Figs. 2 and 3 are both reduced from camera-drawings of E 6004 B.M.; × 5 diam.
4. Transverse section through a brachial (III Br) of *C. acinotubus.* *Br*, body of the ossicle; *ax*, axial canal; *vg*, ventral groove; *cp*, covering-plates. Reduced and restored from camera-drawings of E 1367, B.M.; × 8 diam.
5. A young individual of *C. acinotubus* (?). The extreme length of some of the brachials may be only apparent and due to the difficulty of seeing the sutures; it is, however, noticeable in the young of other genera. From an original drawing of M.P.G. vii $|\frac{4}{84}$; nat. size.

5 *a*. A first primibrach of the same, showing that the axial canal is not yet separated from the ventral groove; × 3 diam.

6. Ventral surface of the calyx of *C. planus* with ambulacrals and interambulacrals removed. Δ, deltoids, and M, madreporite; these surround the peristome, and on their edges are seen indentations for the reception of the ambulacrals; *x*, anal. From E 6007, B.M.; × 2 diam.
7. Ventral surface of the calyx of *C. mammillaris,* Phill., with tegmen complete. Δ, deltoids, in great part covered by *ia,* interambulacrals; *cp*, covering-plates, which are irregular; *x*, anal, which is partly broken. From a drawing by Mr. Hollick of E 288, B.M.; nat. size.

the arms of a single specimen; but, in Silurian forms at all events, each species has usually its own limits.

Anal structures.—Anal *x* from tetragonal to hexagonal; it rests on the upper side of post.B, is in line with RR, and about $\frac{2}{3}$ their width. In typical species it supports, by its horizontal upper side, a smaller plate of similar shape, while on either side of it, in the angle between it and the adjacent radial processes, rests a smaller plate of the tube (*rt* and *lt*). Sometimes *rt* and *lt* appear not to touch *x* at all, in which case *x* is four-sided. Sometimes (e. g. *C. multibrachiatus* from the Keokuk) the upper side of *x* is sloped downwards in such a manner that only *rt* touches the RR, in which case *x* is roughly five-sided.

The Ventral Sac consists of more or less hexagonal plates, arranged in fairly regular longitudinal rows. It varies very greatly in size, but appears never to extend to the length of the arms. It is rounded or swollen, and has a rather large lumen. The plates are solid, often slightly tumid, and sometimes show a radiating structure, which may even exhibit itself in slight folding. In typical species of the genus the foldings are never pronounced, nor are the plates transversely elongate; in none are there slits or pores.

The Tegmen comprises 4 Deltoids and a Madreporite (p. 211, fig. 6). The Deltoids rest on the radial processes, and abut laterally on one another and on the Madreporite. The Madreporite is usually cordiform and appears to be pierced by numerous pores.

Ambulacrals (I Amb) pass between the deltoids and madreporite to the actinal centre, in which region they are usually enlarged (and are by some writers considered to be the Orals).

Smaller Interambulacrals (*i I Amb*) are also often present, almost entirely covering the deltoids (p. 211, fig. 7).

The Stem is rarely preserved to any extent, but it seems never to have attained a very great length. It varies much in width; it is round; with a usually quinquelobate lumen, sometimes of large size. Radial sutures have not been observed.

Columnals rather low, and alternating in thickness and height; or very low and equal in size. They have radiating striæ on their articular surface.

There are no Cirri on the stem.

The Root has not yet come beneath my observation.

Species of the Genus.

Although the Austins in 1846 could deny the existence of

Cyathocrinus in Silurian rocks, we now know a considerable number of Silurian species that may be referred to this genus. The Limestone Beds *d* and *f* of Gotland furnish nine species of *Cyathocrinus*, as described in a paper read before the Royal Swedish Academy of Science on Dec. 9th, 1891 *. The Niagara Limestone of America contains *Cyathocrinus cora*, Hall, *C. waukoma*, Hall, and *C. Van Hornei*, S. A. Miller; but other Silurian species from N. America appear to belong rather to *Botryocrinus*. The Wenlock Limestone of England has as yet presented us with only two species, viz. *C. acinotubus*, Ang., also found in Gotland (*d* and *f*), and a species here described for the first time under the name *C. vallatus*.

As shown in the paper above referred to, the *Cyathocrini* of Gotland fall into three groups. The first of these groups has a stem of moderate width, with rather low and alternately ridged columnals and a more or less conical cup. Both our British species come into this group, and the following synopsis shows the main differences between the species of the group :—

a. Cup with straight sides.

a. Plates plane, granular ..... *C. Dianæ*.

b. Plates axially folded and striate ..... *C. striolatus*.

b. Cup with convexo-concave sides, irregular.

c. Plates plane; smooth or pustulate ..... *C. visbycensis*.

d. Plates tumid; smooth or shagreened ..... *C. acinotubus*.

c. Cup with convex sides.

e. Plates plane; concentrically ridged and pustulate.. *C. vallatus*.

There are of course many other differences between the species than those shown in the above table, but they can be gathered from the diagnoses.

Cyathocrinus acinotubus, Ang.

(Pl. XIII. figs. 1–13.)

1878. *Cyathocrinus acinotubus*, Angelin, Iconographia, p. 22, pl. xx. fig. 5.

1878. *Cyathocrinus alutaceus* (pars), Angelin, Iconographia, pl. iv. fig. 6 *a*.

1873. *Cyathocrinus* (sp. 6) *monile*, nom. nud., Salter, 'Catalogue of Cambrian and Silurian Fossils &c.,' Cambridge, p. 123.

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* F. A. Bather, "The Crinoidea of Gotland, Part I.," Kgl. Svenska Vet.-Akad. Handl. Bd. xxiv. no. 8. In the press.

Cyathocrinus mimus, MS. Museum labels by J. W. Salter.
Cyathocrinus nodulosus, nom. nud. pars, i. e. Museum labels by J. W. Salter, but not the specimen said to be so referred to in Cat. Camb. Sil. Foss. p. 123.

The description, measurements, and diagrams of this species given in this paper are based entirely on British specimens, while in the Swedish paper reference is made throughout to Gotland specimens. Thus any differences due to differing conditions may be more clearly appreciated.

The British specimens examined are the following:—

In the British Museum:

57480, crown and half an inch of stem, seen from the right side, and showing the ventral sac crossing between the arms. Matrix a blue-grey shale. Dudley. From the collection of Mr. S. Allport, and formerly labelled *C. nodulosus*. (Pl. XIII. fig. 1.)

E 1450, crown, free from matrix, which was a very soft yellow shale; shows origin of ventral sac. Dudley. From the collection of Mr. J. Johnson. (Pl. XIII. fig. 2.)

E 5619, the distal end of a ventral sac, referred with hardly any doubt to this species. Dudley. From the collection of Mr. J. Gray, of Hagley. (Pl. XIII. fig. 6.)

57421, crown with 8 to 10 columnals; showing covering-plates well; with a rugose surface produced by weathering. Matrix a blue-grey shale. Tividale, Dudley. (Pl. XIII. fig. 7.)

E 6002, crown with plates of ventral sac well marked, and with a radial facet exposed. Matrix a blue shale. Dudley. Johnson collection. (Pl. XIII. figs. 8 and 11.)

57142, arms with covering-plates and ventral groove well shown. In limestone. Dudley. Gray collection. (Pl. XIII. fig. 10.)

57060, a dorsal cup free from matrix; showing radial facet. Dudley. Gray collection. (Pl. XIII. fig. 11.)

E 6003, dorsal cup, rather broken but very characteristic; showing shagreen ornament. Yellowish matrix. Dudley. From the collection of Mr. J. Rofe. (Pl. XIII. fig. 12.)

E 1367, arms and two thin transverse sections of same. Dudley. Rofe collection. (Zincotype, p. 211, fig. 4.)

E 6004, longitudinal and transverse thin sections of the stem.

Dudley. Rofe collection. (Zincotype, p. 211, figs. 2 and 3.)

57058, basals and infrabasals. Dudley. Gray collection.

57059, a crushed cup. Dudley. Gray collection.

57113, crushed crown and stem-fragment. Dudley. Gray collection.

57141, a crown in hard blue shale. Dudley. Gray collection.

57149, lower part of cup. Dudley. Gray collection.

57362, rather small crown and 1 in. of stem. Limestone. Tividale, Dudley. Gray collection.

57363, arms and upper part of cup. Tividale, Dudley. Gray collection.

57364, crown and $1\frac{1}{4}$ in. of stem. Limestone. Tividale, Dudley. Gray collection.

57365, a small crown, with traces of colour-spots on arms. Tividale. Gray collection.

E 5654, a weathered crown. Matrix a conglomerate of limestone in a yellow marly cement. Probably from Dormington in the Woolhope district (according to Mr. R. Etheridge, F.R.S.). Baber collection.

In the Museum of Practical Geology, Jermyn Street:

vii $\left|\frac{4}{84}\right.$, a young specimen, probably referable to this species, on a slab with *Taxocrinus tuberculatus*. (Zincotype, p. 211, figs. 5, 5 *a*.)

In the Woodwardian Museum, Cambridge:

a/526, 3 well-preserved and characteristic cups, labelled "*Cyathocrinus mimus* (n. sp.)." Dudley. Fletcher collection. (Pl. XIII. figs. 3, 4, 5.)

a/487, 2 or 3 specimens, one showing the covering-plates very well. Labelled "*Cyathocrinus monile*." Dudley.

In the Oxford University Museum:

A crown showing the ventral sac appearing between the arms. Malvern. Grindrod collection. (Pl. XIII. fig. 9.)

Arms showing the ventral surface and covering-plates. Malvern. Grindrod collection. (Pl. XIII. fig. 10 *c*.)

In the collection of Charles Holcroft, Esq.:

206, arms with very large number of ossicles in internodes. Yellowish matrix, Upper Wenlock Limestone. Wren's Nest, Dudley.

For permission to examine and figure certain of the above specimens my thanks are due to Dr. Henry Woodward, F.R.S., the Director-General of the Geological Survey, Prof. T. M^{c}K. Hughes, and Prof. A. H. Green; while a double measure of thanks is due to Mr. Holcroft for allowing me to retain his specimen for several months.

All the above specimens come from the Wenlock Limestone, and many of them come from the Upper Limestone; others, however, are doubtful, and the absence of information prevents us from assigning them to their exact horizon.

The trivial name of this species—derived from *acinus*, a berry, and *tubus*, a tube—probably refers to the blackberry-like appearance of the ventral sac.

Specific Diagnosis.

Dorsal cup bowl-shaped, rather rounded at the base; plates tumid, and smooth or shagreened. Arms rather stout, with rounded ossicles; covering-plates long and conical, from 2 to $3\frac{1}{2}$ to each brachial. Ventral sac large, slightly swollen above; its plates protuberant and rugose. Stem round, of moderate width, with alternate sized ossicles and a quinquelobate lumen.

Description of the Species.

Dorsal Cup is in shape a broad cone, rounded at the base and often projecting radially. The shape, though characteristic (Pl. XIII. figs. 4, 5), is very variable in minor points. Thus, the infrabasals may project at a rather sharp angle with the stem-axis, or may gently curve upwards. The plates, especially the basals, may be very tumid (Pl. XIII. fig. 2); but in a few cases the swelling is inconspicuous. The projection of the radials also varies very much, as seen by comparing fig. 1 with fig. 4 in Pl. XIII. The cup sometimes varies on different sides both in height and in the sizes of its plates, the anterior rays as a rule being the larger in such cases. The average measurements of the cup, as deduced from five specimens, after corrections have been made for compression, are:—Height 13 millim.; width below, 6·9 millim.; width above, 14·8 millim. Extremes of height noted are, in 57365 B. M. 7·2 millim., and in E 6003 B. M. 20 millim. In these and subsequent measurements no account is taken of the young specimen at Jermyn Street or of those in the Woodwardian Museum.

IBB 5, pentagonal and, as a rule, almost equal-sided.

Average measurements, deduced from six specimens, with allowance for variation within the limits of an individual :— Height 3·5 millim.; width below, 3·7 millim.; width above, 4·8 millim. Extreme measurements noted are, in 57365 and E 6003 respectively :—Height 2 millim. and 5 millim.; width below, 2·5 millim. and 4·25 millim.; width above, 3 millim. and 6·8 millim. In E 1450, which is a medium-sized specimen, the height varies from 2·5 millim. in r. ant. I B to 3·2 millim. in l. post., l. ant., and ant. I BB.

BB 5, hexagonal; post.B heptagonal. Average measurements, deduced as above :—Height 6·4 millim.; width below, 5·8 millim., width above, 6·7 millim. Extreme measurements, as above :—Height 3·25 millim. and 10 millim.; width below, 3·5 millim. and 8 millim.; width above, 4·2 millim. and 9·5 millim. These measurements do not take the posterior basal into account: that is always a little larger every way than the others; thus, in E 1450, the measurements of the post.B and of the other BB are as follows :—Height 6 millim. and 5·5 millim.; width below, 5·75 millim. and 5·4 millim.; width above, 7 millim. and 6 millim.

RR 5, shield-shaped, often projecting slightly in some or all of the rays. Average measurements, deduced as above, are :—Height to bottom of facet 9·95 millim.; width below, 13·9 millim.; width above, 14·9 millim.; width of facet 8·7 millim. Extreme measurements, as above, are :—Height 3 millim. and 8 millim.; width below, 4·2 millim. and 9·5 millim.; width above, 4 millim. and 11·25 millim.; width of facet 3·25 millim. and 6 millim. The adjacent sides are usually almost parallel in medium-sized specimens, and even converge upwards in small specimens. From the above measurements and others it appears that, while the average width of the facet is ·577 *, or rather more than half, that of the radial, it is proportionally greater in small individuals, *e. g.* ·81 in 57365, and less in large individuals, *e. g.* ·53 in E 6003. The facet is sometimes more to one side of the radial than the other; it is transversely elliptical in outline (Pl. XIII. fig. 11). A fulcral ridge runs across, a little outside the long diameter, and in the centre of this ridge is the axial canal. The food-groove forms a wide depression on the inner side of the ellipse. Partly owing to the variation in the projection of the radials, the angle at which the facet is directed outwards varies considerably even in the same specimen. In the separate cups found at Klinteberg, in Gotland, which lend themselves to such measurement more

* These numbers are fractions of the width of the radial, not of a millimetre.

readily than the English specimens, the angle with the horizontal varies between 35° and 85°.

The average measurements of the Gotland specimens are considerably greater than those of the English specimens, but no other difference is obvious.

In such very well-preserved specimens as E 6003 (Pl. XIII. fig. 12) a fine shagreen ornament is seen on the cup-plates; this, however, is usually worn away, and it may be doubted, from the smoothness of some otherwise perfect specimens, *e. g.* E 1450, whether it was always present in life. In the fossils its place is occasionally taken by a rough surface, that presents much the same appearance to the naked eye, but which consists of irregular pits rather than elevations (Pl. XIII. fig. 7). This roughness appears to be caused by weathering along the lines of the original intimate structure of the plates. A specimen of this species, so weathered, was named by Angelin *C. alutaceus*.

The Arms dichotomize regularly, and lessen in thickness quite gradually, remaining rather stout even to their extremities. The ossicles are rounded and slightly swollen, and often might be described as moniliform, whence, no doubt, Salter's MS. names of *C. monile* and *C. nodulosus*; sometimes, however, they are more even in thickness. In the proximal region of the arms the brachials are roughly circular in transverse section, but become more laterally compressed in the distal region (zincotype, p. 211, fig. 4). The axial canal is very distinct and is situated just about the middle of the ossicle. The ventral groove is a broad, curved, shallow depression (Pl. XIII. fig. 10 *b*). In the young specimen (zincotype, fig. 5 *a*) the axial canal is not yet separated by stereom from the ventral groove, even in the primibrachs. The covering-plates are long, thick, and conical both in outline and longitudinal section (Pl. XIII. figs. 10 *a*, 10 *c*, and zincotype, fig. 4). They interlock, and run from two to three and a half to each brachial. They are sometimes rather flat and narrow, with parallel sides, at other times more rounded and conical; the former variety is shown in the top left-hand corner of Pl. XIII. fig. 2.

I Br from 3 to 5. When there are 3 then I Br_2 is generally twice as high as I Br_1; when there are 4 then I Br_2 and I Br_3 are usually much higher than the rest; when there are 5 they are all more of a size. Three is by far the commonest number. The number of I Br may vary in the several arms of an individual, but is generally the same.

II Br from 2 to 4. As with I Br, 3 is the usual number, and II Br_2 is often higher than II Br_1.

III Br from 3 to 7. The lower numbers are more usual, and the higher numbers, when they occur, are in the branches on the inner side of the dichotom; thus, the left posterior arm of E 1450 (Pl. XIII. fig. 2) has III Br, counting from left to right, —3 . 4 . . 6 . 4 *. Here, too, the second ossicle is sometimes higher than the first.

IV Br from 3 to 9. In this case the lower numbers are in the branches on the outside of the arm, the higher numbers on the inside of the dichotoms, and the middle numbers on the inside of the arm. This arrangement will be better understood from an actual example: in 57362 B. M. the quartibrachs run thus, from left to right—4 . 8 . . 9 . 7–6 . 6 . . 7 . 5.

V Br from 3 to 11. Generally speaking these numbers follow the same sort of arrangement as in previous series, but the higher numbers are often finials, especially in rather young specimens. Thus in an arm of 57480 B. M. (Pl. XIII. fig. 1), starting from the middle or inner side of the arm and passing towards the outer side on the right, the numbers run as follows, *f* being placed against the finials—6 . 9 . . 8*f*. 6*f*–6 . 9*f*. . 9*f*. 8.

VI Br from 2 to 14. Many of these are generally finials, and in young specimens even the lower numbers are finials. Otherwise the arrangement is much as in the quintibrachs.

VII Br are only found in well-grown specimens. The numbers observed are 3 and 4. They are always finials; but it is of course conceivable that the arms might branch yet once more in an exceptionally well-favoured individual. If, however, finials appear in any one series, it seems to be the rule that all of the ensuing series shall be finials; that is to say, in no single arm does one branch ever get more than one series ahead of the other.

The above numbers do not take account of 206 Holcroft, in which the series are rather longer, 17 being seen in one internode.

Anal structures.—The measurements of anal *x* in E 1450 are as follows:—Height 4·5 millim.; width below, 3·8 millim.; width above, 4·75 millim.; that is to say its width is about $\frac{3}{5}$ that of the adjacent radials (Pl. XIII. fig. 2). It supports a large proximal median plate and a smaller plate on either side (*rt* and *lt*). The latter plates rest partly on the adjacent radials.

The Ventral Sac is about half the length of the arms or

* In this and in the ensuing examples the peculiar spacing of the numbers is an attempt to represent the bilateral symmetry of the arm: the two branches of each dichotom are separated by only a single full-stop.

less; it is rounded and somewhat swollen above (Pl. XIII. figs. 1, 2, 6, 9). The plates of which it is composed are hexagonal in the proximal region, but distally they become irregular in outline. The size of the plates varies considerably, but their transverse diameter is as a rule between 1·5 and 2·5 millim., their vertical diameter being rather less. The plates are sometimes quite smoothly rounded or almost flat (Pl. XIII. fig. 1); sometimes they are slightly folded at the edges, the folds being at right angles to the sutures (Pl. XIII. fig. 9): in E 6002 this folding is very clearly marked, and at the same time it is quite obvious that there are no pores or slits within the folds (Pl. XIII. fig. 8). In the separate distal end of a sac shown in Pl. XIII. fig. 6, the surface of the plates appears rather curiously pitted; this, however, is no doubt due to weathering, and may be compared with the roughness already alluded to (Pl. XIII. fig. 7).

The Tegmen is unknown.

The Stem (Pl. XIII. figs. 1 and 13; zincotype, p. 211, figs. 2 and 3) is round, composed of ossicles which alternate both in height and width with fair regularity. The following are a few measurements of the heights of the ossicles:—In E 6004 (fig. 2, p. 211) the respective heights of the ossicles are about 1·16 millim. and ·59 millim.; in 57362 B. M. they are 1 millim. and ·55 millim.; in 57364 B. M., in a more proximal part of the stem, the ossicles are of three sizes with heights 1 millim., ·75 millim., and ·2 millim. The width of the stem is between 5 millim. and 7 millim. The lumen is quinquelobate and its diameter is about $\frac{1}{3}$ that of the stem, or a little less. The articular surface of each ossicle is slightly concave, and is radiately striated. In the longitudinal section the space between the concave articular surfaces is filled with transparent calcite, while the lumen itself is filled with opaque matrix. This probably results from the fact that the interarticular ligaments decayed more gradually than the axial cord and its blood-vessels, and that, after the place of the latter had been taken by infilling ooze, they themselves were gradually replaced by the infiltration of carbonate of lime. We may now note, both in the longitudinal and transverse (fig. 3) sections, that the stereom of the ossicles is separated from the matrix in the canal by a thin film of calcite; this too, then, must represent some lining membrane or ligament.

The base of the cup is often slightly excavated for the top columnal (Pl. XIII. fig. 4).

Cyathocrinus vallatus, sp. n.
(Pl. XIII. figs. 14–18.)

This species is based on three specimens, viz. :—

In the British Museum :

(*a*) E 6005, a somewhat worn cup in matrix. Gray collection. (Pl. XIII. fig. 18.)

(*b*) E 6006, a cup still more worn, especially in the distal region, and ground down at the sides; in matrix; seen from the right side. Gray collection. (Pl. XIII. fig. 15.)

In the Museum of Mason College, Birmingham :

(*c*) 170, a better preserved cup, showing articular facets for stem and arms; in matrix. (Pl. XIII. figs. 14, 16, 17.)

These specimens all come from the Wenlock Limestone of Dudley, but the exact horizons and localities are uncertain. They are all in a rather yellowish shale, on the top of a limestone; it is therefore probable that they come from the Upper Wenlock Limestone.

For permission to figure the specimens in the British Museum I am indebted to Dr. Henry Woodward, F.R.S.; while for the loan of specimen *c* Prof. C. Lapworth deserves my best thanks.

The trivial name *vallatus*, which means *encircled by a ridge*, refers to the characteristic ornament of the cup-plates.

Specific Diagnosis.

Dorsal cup rather elongate, with convexly rounded sides; plates plane, with a strong concentric ridge at a short distance from the suture, and with irregular concentric or slightly radiating ornament on the inner part. Axial canal not separate. Stem with a large quinquelobate lumen. Arms, ventral sac, tegmen, and stem unknown.

Remarks on the Species.

Dorsal Cup has a somewhat ovoid curve, bulging more in the region of the basals. The measurements of the specimens are as follows :—

	Height millim.	Width below. millim.	Width above. millim.
(*a*).....	23	8 (?)	21 (?)
(*b*).....	23	7·25	23 (?)
(*c*).....	19·75	8	21 (?)

I BB 5, pentagonal, rather wider than high.

	Height. millim.	Width below. millim.	Width above. millim.
(*a*).....	6	4·75	7·75
(*b*).....	5·5	4·2	7
(*c*).....	5·5	4	6·5

BB 5, hexagonal; post.B, seen partially in *b*, heptagonal.

	Height. millim.	Width below. millim.	Width above. millim.
(*a*).....	12	9·5	11·5
(*b*).....	10·2	8·5	11
(*c*).....	10·75	8	10·5

The measurements of post.B are height 12 millim. in *b*; otherwise unknown.

RR 5, shield-shaped; projecting in a slight bulge just below the articular facet, but not curving inwards much towards the radial processes. The facet is smoothly concave, with a very slight trace of a ridge; the axial canal is not separated from the ventral groove by stereom, but, together with it, forms a deep notch. Measurements are:—

	Height. millim.	Width below. millim.	Width above. millim.	Width of facet. millim.
(*a*)....	8·8	12·25	12	6
(*b*)....	8·5 (?)	10	10·5	?
(*c*)....	7·2	10·3	10·3	5

From which it appears that the sides of the radials are almost parallel and that the width of the facet is just half that of the radial. The facet is almost at right angles to the slope of the side and is therefore directed almost upward.

A portion of anal *x* is preserved in *b*. It is about 6·5 millim. high and about 5 millim. wide below.

A portion of *rt* is also preserved in this specimen.

A marked concentric ridge surrounds all the cup-plates at a distance of about ·75 millim. from the suture. There is also an irregular ornament on the plates, which tends to run in concentric circles (Pl. XIII. fig. 18), or may have a more radiate arrangement (Pl. XIII. fig. 14).

The characters of the *Stem* may be inferred from the bottom of the cup, which shows a very large quinquelobate axial canal, shown in Pl. XIII. fig. 17, where it has a mean

width of 4·2 millim., or a little more than half the probable width of the stem. The facet for the stem is radiately striated. The stem was therefore probably like that of *C. acinotubus*.

In the general shape of the cup and in its probable stem-characters the species resembles the group of *C. acinotubus*. The shape of the cup is most like that of *C. acinotubus*, and indications of the ridge that is here so marked may also occasionally be seen in that species. The ornament, however, more resembles that of *C. visbycensis*, var. *monilifer*. In the notched facet and imperforate articulation this species differs from most Silurian *Cyathocrini*; but such a stage of development is occasionally presented by *C. striolatus*, which belongs to the same group. The large size of the cup is a character of no great importance, but affords a ready means of distinguishing the species in British collections.

General Remarks on the Genus.

The British specimens do not throw much light on the morphology of the genus, so that there are very few points to which attention need be here directed.

Growth of the cup.—From the various measurements of the plates of *C. acinotubus* given on p. 217, it seems to follow that the facets of the radials, and consequently the arms, are wider in proportion in the young than in the adult; also that the radials are proportionally wider below in the young. This latter fact harmonizes with the statements already made in general terms by Messrs. Wachsmuth and Springer * and Mr. S. A. Miller † as to the infrabasal and basal plates of Crinoids being more largely developed in the young than the other plates of the cup. That statement too, it may be mentioned, is confirmed by the measurements made of the present species. It is extremely interesting to note how closely the growth of this Silurian Crinoid agrees with the growth of the Pentacrinoid larva of a recent *Antedon* ‡. But it would be advisable to tabulate the measurements of large series of many other species before laying down any general laws as to the growth of Silurian Inadunate Crinoids.

The Axial Canal of the Arms.—So much was said about

* Rev. I. 19, Proc. 1879, p. 242.

† "Structure &c. of American Palæozoic Crinoids into Families," Amer. Geol. vol. vi. p. 282, line 11, Nov. 1890; and 'American Geology and Palæontology,' p. 212, Cincinnati, 1889.

‡ See W. B. Carpenter, "Researches on the Structure, Physiology, and Development of *Antedon* (*Comatula*, Lamk.) *rosaceus*," Phil. Trans. 1866, pp. 727, 29, 731.

this in the earlier part of the paper (p. 209), that it is only necessary to point out that a Silurian species is here described, from specimens of mature growth, in which the axial canal is not separated from the ventral groove in the radial facet: in this point *C. vallatus* resembles Carboniferous species of *Cyathocrinus*. Further evidence, if such be needed, to show that the non-separation of the canal is merely a youthful character, and therefore also an archaic one, may be adduced from the young specimen at Jermyn Street (p. 211, fig. 5 *a*). Consequently it is not in itself a character very suitable for the discrimination of genera.

The Covering-plates of the Arms.—It does not appear from the present paper, but it will be seen from the descriptions of the Gotland *Cyathocrini* that, although the number of these that goes to an ossicle is variable, yet there are limits to the variation, by the recognition of which we are often able to determine species when other means fail us.

In describing these structures, Messrs. Wachsmuth and Springer have mentioned (Rev. I. 84, Proc. 1879, p. 307) that the groove "is provided with two rows of from two to five successive movable plates, alternately arranged on opposite sides." It is, however, undoubtedly the case, as shown by Pl. XIII. fig. 10, that the row on either side may be only one plate deep. It is quite true that there are sometimes two plates in the row, a small narrow plate lying at the base of and alternating with each of the regular conical covering-plates (see Angelin, Iconogr. tab. xxvi. fig. 5 *b*). Occasionally too there occur small, usually rather irregular plates, over the middle line, between the two rows of regular covering-plates. This might make three or conceivably four rows on either side (see W. & S. Rev. III. Proc. 1885, pl. iv. fig. 7 *b*). But in asserting that there were sometimes five rows it is possible that Messrs. Wachsmuth and Springer were misled by Angelin's tab. xxvi. fig. 4, which represents the covering-plates of *C. ramosus* (wrongly called there *C. longimanus*); for these plates are marked by transverse lines that divide them into five parts, and produce the impression that each covering-plate is composed of five ossicles, which is not really the case.

The Ventral Sac.—Messrs. Wachsmuth and Springer stated in 1879 (Rev. I. 84) that pores and slits had been observed in the ventral sac of Silurian species of *Cyathocrinus*. This statement has never been withdrawn by them, though in their recent paper on the Perisomic Plates * they seem to imply

* Proc. Acad. Nat. Sci. Philadelphia (1890), Part III. See p. 360, February 1891.

that the ventral sac of the Cyathocrinidæ generally is not perforate. It is possible that they were formerly misled by the erroneous reference to *Cyathocrinus* of many species of *Gissocrinus*, *Botryocrinus*, and such forms in which the ventral sac often appears at first glance to be provided with slits between the edges of the plates. At any rate none of the sacs of the Silurian *Cyathocrini* that have come under my observation appear to possess either pores or slits. Deceptive appearances are sometimes produced by weathering, as described under *C. acinotubus* (p. 220); and sometimes the edges of folded plates are filled with matrix which everyone does not take the trouble to clear away.

The Tegmen.—As none of the British Silurian specimens show the tegmen it is advisable to defer discussion of the many important problems presented by it. Original drawings of two Carboniferous specimens are, however, given (p. 211) in illustration of the description of the genus. The one (fig. 6) shows the deltoids and the madreporite surrounding the peristome; the other (fig. 7) shows how both deltoids and peristome may be covered by ambulacrals and interambulacrals, though portions of the deltoids are still seen peeping out from beneath the interambulacrals. The questions to be decided are these:—What are the true homologies of the plates here called deltoids? Is the madreporite serially homologous with the deltoids? Or is the posterior deltoid represented by *two* plates, one on either side of the madreporite? Are the plates that cover over the peristome, which are sometimes large and fairly regular, sometimes small and irregular, orals or merely large ambulacrals?

EXPLANATION OF PLATE XIII.

Cyathocrinus acinotubus.

Fig. 1. 57480, B. M. A crown with portion of stem, seen from the right side. The ventral sac seen crossing between the arms. Drawn with the camera by Mr. Hollick. (Nat. size.)

Fig. 2. E 1450 B. M. Crown seen from posterior. Drawn with the camera by Mr. Hollick. (Nat. size.)

Fig. 3. *a*/526, Woodwardian Museum. A small cup, seen from below, with one or two columnals attached. Note large size of IBB. From a drawing by Mr. Edwin Wilson, artist to the Cambridge Engraving Co. (Nat. size.)

Fig. 4. *a*/526, Woodwardian Museum. Cup seen slantwise from below, showing projection of radials. One very pentagonal columnal seen inserted in the IBB circlet. From a drawing by Mr. E. Wilson. (Nat. size.)

Fig. 5. *a*/526, Woodwardian Museum. Cup seen from posterior, showing *x* and *lt*. From a drawing by Mr. E. Wilson. (Nat. size.)

Fig. 6. E 5619, B. M. A ventral sac, slightly weathered. From a drawing by Mr. Hollick. (× 2 diam.)

Fig. 7. 57421, B. M. A small portion of the weathered surface of a radial. From a drawing by Mr. Hollick. (× 10 diam.)

Fig. 8. E 6002, B. M. A plate from the proximal region of the ventral sac, to show the folding of the edges. Drawn on stone by the author. (× 3 diam.)

Fig. 9. Grindrod Collection, Oxford. The distal end of the ventral sac appearing between the branches of the anterior arm. Drawn on stone by the author. (Nat. size.)

Fig. 10 *a*. 57142, B. M. Three brachials seen from the side, showing the covering-plates open.

b. 57142, B. M. The ventral surface of three brachials, the covering-plates removed and the ventral groove exposed.

c. Grindrod Collection. The ventral surface of three brachials, the covering-plates *in situ* and closed.

All from drawings by the author. (× 3 diam.)

Fig. 11. 57060 and E 6002, B. M. A radial showing the articular facet, combined from the evidence of these two specimens. From a drawing by the author. (× 3 diam.)

Fig. 12. E 6003, B. M. Portion of surface of a radial, showing shagreen ornament. From a drawing by Mr. Hollick. (× 10 diam.)

Fig. 13. The articular surface of a stem-ossicle from the evidence of numerous specimens. From a drawing by the author. (× 3 diam.)

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Fig. 14. 170, Mason College. A radial seen obliquely from above, to show articular facet; also showing ornament. From a drawing by Mr. Hollick. (× 2 diam.)

Fig. 15. E 6006, B. M. A cup seen from the right side, showing post.B and *x* on the left; outline restored. From drawings by Mr. Hollick and the author. (Nat. size.)

Fig. 16. 170, Mason College. A cup; orientation uncertain. From a drawing by Mr. Hollick. (Nat. size.)

Fig. 17. The articular facet for the stem of the same specimen. From a drawing by Mr. Hollick.

Fig. 18. E 6005, B. M. A much weathered cup; orientation uncertain. From drawings by Mr. Hollick and the author. (Nat. size.)

XXXIII.—*On some Spiders from the Andaman Islands collected by E. W. Oates, Esq.* By Prof. T. Thorell.

Our knowledge of the arachnological fauna of the Andaman Islands is as yet exceedingly limited; so far as I know M. Eugène Simon is the only author who has, in a recently-published paper *, enumerated and described any spiders

* "Études sur les Arachn. de l'Asie mérid. faisant partie des collections de l'Indian Museum (Calcutta).—II. Arachn. recueillis aux îles Andaman par M. R. D. Oldham," in Journ. of the Asiatic Soc. of Bengal, lvii. part ii. no. 3 (1887).