CHAPTER XVII.

Radial Series: Echinodermata.

As seen in the majority of adult Echinoderms the repeated parts are arranged with a near approach to a Radial Symmetry and it is thus convenient to consider their Meristic Variations in that connexion. But it must of course always be remembered that in their development these repetitions are in origin really a Successive Series and not a Radial Series. The segments are not all identical (as, in appearance at least, they are in many Cœlenterates &c.), but are morphologically in Succession to each other, though there may be little differentiation between them.

In the case therefore of Variation in the number of segments, resulting in the production of a body not less symmetrical than the normal body, there must be in development a correlated Variation among the several members like that seen in so many cases of additions to the ends of Linear Series.

This circumstance should be kept in view by those who seek in cases of numerical Variation, in Echinoderms to homologize separate segments of the variety with those of the type, hoping to be able to say that such a radius is added, or such other missing. As in other animals, this has been attempted in Echinoderms, and though I know well that in the complex subject of Echinoderm morphology I can form no judgment, yet it is difficult to suppose that the same principles elsewhere perceived would not be found to hold good for Echinoderms also.

All that is here proposed is to give abstracts of facts as to Variation in the numbers composing the Major Symmetries. It will of course be remembered that though the fundamental number in Echinoderms is most commonly five, other numbers also occur as normals, (*e.g.* four in the fossil *Tetracrinus*, six in some Ophiurids, &c. Examples will be given of total change from five to four and to six, and so on. It is besides not a little interesting that of the normally 4-rayed *Tetracrinus* both 5-rayed and 3-rayed varieties should be known.

Besides the examples of total Variation there are a few cases of incomplete Variation in which there is a fair suggestion that

a particular ray is reduced in size (Nos. 680 and 681, &c.). There are also two cases of imperfect division of a ray in an Echinid (Nos. 688, &c.), while in Asteroids &c. this condition is common. It is of importance to observe that just as in Linear Series abnormal divisions of members of the series are commonly *transverse* to the lines of Repetition, so in radial forms the divisions of rays are commonly *radial*.

The evidence is complicated by the fact that in many Echinoderms extensive regeneration can occur, and in some genera reproduction by division of the disc and subsequent regeneration is almost certainly a normal occurrence[1]. Nevertheless it cannot be doubted that the variation seen in Echini, in *Asterina*, in the discs and stems of Crinoids, &c., are truly congenital. Similarly, though in *Asterias* &c. reduction in the number of arms might otherwise be thought to be due to mutilation, it cannot be so in Echini &c.

HOLOTHURIOIDEA.

*642. **Cucumaria planci:** among 150 half-grown specimens found at Naples five were 6-rayed. LUDWIG, H., *Zool. Anz.*, 1886, IX., p. 472. [These specimens are described in detail.] To determine which is "the intercalated ray" the following ingenious reasoning is offered, and as a good practical illustration of the conception of the individuality of segments as applied to an Echinoderm we may well consider it.

[1] It is likely that several of the Ophiurids and Asteroids which normally have more than 5 arms undergo such fission. LÜTKEN (*Œfvers. Dansk. vid. Selsk. Förh.*, 1872, pp. 108—158: tr. *Ann. and Mag. N. H.*, 1873, S. 4, XII. pp. 323 and 391) gave an account of this phenomenon. *Ophiothela isidicola* (Formosa) generally has 6 arms, rarely equal, usually 3 large opposite to 3 small; specimens common with only 3 arms, with appearance as if corresponding half-disc cut off. There can be no doubt that the animal divides and that the other 3 arms are renewed. The same phenomenon has been seen in other small 6-armed Ophiurids, especially of genus *Ophiactis*, but Lütken never saw any trace of it in any normally 5-rayed species of the genus. There are indications that the division occurs once when the animal is very small and again when it is adult or nearly so. In *Ophiocoma pumila* the *small* specimens have 6 arms, while the *adults* have 5. Probably therefore division only occurs in the young, the last division being followed by the production of 1 or 2 arms instead of 2 or 3.

Division is probably not a usual occurrence even in Ophiurids having more than 5 arms. *Ophiacantha anomala* has normally 6 arms, and *O. vivipara has* 7—8, but no such appearances are known in them.

Similarly there is evidence [figs. given] that certain Asteroids having normally more than 5 arms viz. *Asterias problema* Stp. [=*Stichaster albulus*], *A. tenuispina* &c. undergo fission; but there is no reason for believing that other many-armed Asteroids divide. The Solasters have many rays, *Asterias polaris* has 6, but no signs of division are seen in them.

An account is also given of the comet-like specimens of *Ophidiaster cribrarius*, occasionally found, having one long arm, at the adoral end of which are present 4 or 5 arms as mere tubercles or as half-grown structures. This phenomenon is well known in *Linckia multiflora*, in which doubtless the separate arms may break off, each reproducing complete disc and arms. [See also as to *Stichaster albulus*, *Asterina wega*, &c., CUÉNOT, L., *Arch. zool. exp.*, V. *bis*, 1879—90, p. 128; and as to *Linckia*, SARASIN, *Ergeb. naturw. Forsch. auf Ceylon*, 1888, I. *Hft.* 2.]

In the normal there are 5 radii and interradii, and 10 tentacles: in the abnormals there are 6 and 12 respectively. In half-grown normals the 3 ambulacra of the ventral trivium have more tube-feet than the 2 ambulacra of the bivium; also the pair of tentacles corresponding to the central radius of the trivium are smaller than the rest. In the abnormals 3 ambulacra have more tube-feet and are separated by narrower interradii than the rest, and of them the central has the least pair of tentacles: therefore these are the 3 radii of the ventral trivium, and of them the central is the central of the normal. The structure of the calcareous ring bears out this correspondence. The central radius of the ventral trivium is therefore *not* the intercalated radius.

In the 6-rayed specimens there is thus a ventral trivium and a 'dorsal trivium.' (There were 2 Polian vesicles in 3 specimens, 3 in one and one in the other, but in the normal also these vary in number.) The stone-canal was single in all; but in one of them it could be seen that the canal arose in the interradius *to the left* of that which bore the madreporic plate, suggesting that the radius thus crossed was supernumerary; for in a normal the interradius of the dorsal mesentery is in the centre of the bivium. In a normal there are in the calcareous ring two radials on either side between the dorsal mesentery and the ventral median radius. In 4 of the abnormals (to which alone what follows refers) there were 3 such radii on the left and 2 on the right, while in the 5th specimen there were 3 on the right and 2 on the left.

The respiratory trees of the normal are in the right interradius of the bivium and in the left interradius of the trivium. In the 6-rayed they are in the left interradius of the ventral trivium and in the lower right interradius of the dorsal trivium, agreeing with the normal and shewing that the right radius of the ventral trivium is *not* an intercalated one. Next, the mesentery in its course traverses in the 6-rayed form 4 radii and 3 interradii, the lower right interradius of the dorsal trivium with its 2 adjacent radii alone being free. In the normal, 3 radii and 2 interradii are thus traversed, the right bivial interradius and its 2 adjacent radii being free. Therefore the right radius of the dorsal trivium and of the ventral trivium are *not* intercalated. The central radius of the ventral trivium has already been excluded; therefore the intercalated segment is either the middle or the left of the dorsal, or the left of the ventral trivium.

In a normal, the mesentery which is attached to the alimentary canal at that place where its upward portion again turns downwards comes from that interradius which bounds the ventral trivium on the left. This is the case also in the abnormals, and therefore the left radius of the ventral trivium is *not* intercalated. Of the two remaining radii the left of the dorsal trivium is in nowise abnormal, but the central dorsal radius is abnormal in that it is crossed by the sand-canal, therefore *the central dorsal* is the intercalated radius.

And since in four cases there were three radii in the calcareous ring on the left, between the interradius of the stone-canal and the central of the ventral trivium, and two on the *right*, therefore the new segment is in them intercalated on the *left* of the median interradius of the bivium; while in the fifth specimen the intercalation has been made on the *right* of the same interradius.

Now all this argument rests on the premiss that the several members of a series of differentiated parts *cannot* undergo a Substantive Variation in correlation with Meristic change in the total number of members constituting the series. It is assumed that there can be no redistribution of differentiation.

This assumption has now in many cases of Linear Series been shewn to be false. To refer to one of the simplest cases, there is, in the case of the Frog, evidence that the peculiarities of the 9th vertebra may be wholly or in part transferred to the 10th vertebra, when by Meristic Variation there are 10 vertebræ (Nos. 56, 57 and 60), and the like has been shewn in many other examples (cp. No. 35). The functions (as indicated by the structures) of the vertebræ may be redistributed on the occasion of Meristic Variation.

Will anyone affirm that similar redistribution of differentiation may not happen in the Meristic Variations of Echinoderms?

643. *Variations in organs of Holothurioidea.* LAMPERT calls attention to the great variability found in this group and the consequent difficulty in distinguishing specific characters from individual abnormalities. These variations often take the form of alterations in the number of organs. For example, the distribution of the tube-feet is liable to great alterations during the lifetime of individuals. In some forms (as *Thyone* and *Thyonidium*) the feet are confined to the ambulacral areas in the young animal, but are distributed over the whole body in more mature individuals; and in species of the genus *Stichopus*, though the tube-feet are arranged in rows, yet in old individuals this arrangement may become obliterated. On the contrary, in others, as for example, *Holothuria graeffei*, the arrangement of the feet in thoroughly mature specimens is still most sharply defined.

The number of the tentacles is generally a multiple of five, and such cases as *Amphicyclus* and *Phyllophorus* in which other numbers are found, are rare. In these forms the tentacles are said to vary both in number, position and size, but the number is always about 20. The case of *Thyonidium molle* is cited as an extreme case. Of this species 4 specimens had 20 tentacles arranged in a paired manner as in typical *Thyonidia*; other specimens had 20 tentacles of similar length; others had from 16 to 19 tentacles of nearly equal lengths, and others again had from 19 to 21, which instead of being disposed in pairs were placed irregularly, some being larger and some smaller.

Of all the organs, the Cuvierian organs are the most variable and they are of little value for purposes of classification. Their number is very inconstant and they may even be absent altogether. It is impossible to distinguish any circumstances whether of locality or of structure in which the individuals without Cuvierian organs differ from the others which possess them. The two chief appendages of the water vascular ring, namely Polian vesicles [cp. No. 642] and the stone-canal are usually constant when they are single, but in rare cases there are exceptions even to this rule. If however more than one of these organs is normally present, it may generally be assumed that there is no constancy in their numbers, and in such cases the number of the Polian vesicles is especially variable. A few species have been recorded in which, from a single Polian vesicle, secondary ones are formed by lateral outgrowths.

The calcareous plates are of all the organs the least liable to variations, but in certain cases they are stated to change with age.

LAMPERT, K., *Die Seewalzen*, in *Semper's Reisen im Archipel der Philippinen*, 1885, IV. III. pp. 6, 13, and 174; also in *Biol. Centrabl.* v. p. 102.

CRINOIDEA.

Variation from the pentamerous condition has been many times observed, though considering the vast number of specimens collected

it must be a rare occurrence. In *Tetracrinus* the four-rayed condition is normal, and it is an especially interesting circumstance that in this form Variation to both a five-rayed and to a three-rayed condition has been observed. For nearly all the references to the following facts I am indebted to the useful collection of evidence on the subject given by BATHER, F. A., *Quart. Jour. Geol. Soc.*, 1889, p. 149.

Four-rayed varieties of five-rayed forms[1].

644. **Holopus rangi.** This genus was originally described from a 4-rayed specimen by D'ORBIGNY, *Mag. de Zool.*, 1837, Cl. x., Pl. III. Subsequently, 5-rayed examples were obtained and this condition was found to be normal (see CARPENTER, *Chall. Rep.*, XI., Pt. XXXII., p. 197).

645. **Eugeniacrinus:** departure from 5-rayed condition very rare. Among many hundreds of calyces in Brit. Mus. one only is 4 rayed, BATHER, *l. c.*, p. 155.

646. **E. nutans:** 4-rayed specimen at Tübingen figured in QUENSTEDT'S Atlas to *Petrefactenk. Deutschl.* Taf. CV., figs. 179—181. Another case GOLDFUSS, *Petrefacta Germaniæ*, I., p. 163, Pl. I., fig. 4, now in Poppelsdorf Mus., Bour. (Bather).

647. **E. caryophyllatus:** 4-rayed specimen seen at Stuttgart. Such a specimen [? the same] ROSINUS, *Tentaminis de Lithozois...Prodr.* &c., tab. III. (Hamb. 1719). Another case GOLDFUSS, *l.c.*, fig. 4: now in Poppelsdorf Mus. (Bather).

648. **Pentacrinus:** a 4-rayed stem-joint from the Chalk, MANTELL, G. A., *Geol. of Sussex*, 1822, p. 183 : now in Brit. Mus., E. 5501 (Bather).

649. **Pentacrinus jurensis:** 4-rayed specimen. The stalk had only 4 sides, one being quite flat. This flat side had an articulation for a cirrus. DE LORIOL, P., *Paléont. Franç. Terr. jur.*, Ser. 1, Paris, 1886, p. 112, Pl. CXLIV., *fig.* 6.

650. **P. subsulcatus:** 6 joints of a 4-rayed stem, *ibid.*, p. 117, Pl. CXLV., *fig.* 2.

651. **P. dumortieri:** 8 joints of a 4-rayed stem, *ibid.*, 1887, p. 186, Pl. CLXII., figs. 6 and 6 *a*.

652. **P. dubius:** 4-sided stem quite regular. Basle Mus., BATHER, *l.c.*, p. 168.

653. **Balanocrinus subteres:** 4-sided stem quite regular. *ibid.*

654. **B. bronni:** "the articular surface shows 4 sectors quite regularly disposed; this peculiar character is continued over the whole series of joints, 26 in number." *ibid.*

655. **Encrinus fossilis:** a 4-rayed calyx, &c., v. STROMBECK, A., *Ztschr. d. deut. geol. Ges.*, I., 1849, p. 158 *et seqq.* See also *Palæontographica*, 1855, IV., p. 169, Pl. XXXI. figs. 1 and 2.

656. **E. fossilis:** two 4-rayed calyces with mutilated arms, v. KOENEN, *Abh. k. Ges. d. Wiss.*, Göttingen, 1887, XXXIV. *Phys. Kl.*, p. 23.

657. **Antedon rosacea:** 4-rayed specimen, CARPENTER, P. H., *Chall. Rep.*, XXVI. Pt. LX. p. 27. Four-rayed Japanese specimen, *ibid.* Another in Brit. Mus. *ibid.*

[1] 4-sided stem joints undetermined. PUSCH, *Polens Paläont.*, 1837, p. 8, Pl. II. fig. 8, *a*, *b*, *c*, *d*. See also AUSTIN, *Ann. and Mag. N. H.*, 1843, XI. p. 203.

658. **Actinometra paucicirra:** 4-rayed specimen, *ibid.* "In all these [Nos. 657 and 658] the anterior ray (A) is missing, so that the mouth, instead of being radial in position is placed interradially between the rays E and B." CARPENTER, *l. c.*

Compare the following case of *imperfect* change towards the 4-rayed state:

659. **Cupressocrinus crassus:** abnormal calyx (now referred to this species, see BATHER, *l. c.*, p. 169) has one segment of the calyx reduced in size and bearing no radial plate or arm. This reduced segment is covered in by the adjacent segments so that the calyx as a whole is regularly 4-sided. GOLDFUSS, *Nova Acta Ac. C. L. C.*, 1839, XIX. p. 332, Pl. XXX., figs. 3 *a* and *b* [cp. No. 665].

Six-rayed varieties of five-rayed forms.

660. **Actinometra pulchella:** doubtful case of six rays, CARPENTER, *l. c.*

661. **Antedon** sp. Six-rayed specimen. "The additional ray is inserted between the two of the right side (D and E)." CARPENTER, *l. c.*

662. **Rhizocrinus lofotensis:** 6-rayed specimen. Four and six rays stated to be more common in *Rhizocrinus* than in other recent Crinoids; seven rays are also found, but very rarely. In *Pentacrinus* no 6-rayed specimen seen. CARPENTER, P. H., *Chall. Rep.*, XI. Pt. XXXII. p. 38, Pl. VIII. *a*, figs. 6 and 7.

*663. **Pentacrinus jurensis** (probably): stalk with 6 sides. [Fig. represents two adjacent lobes of the stalk as smaller and closer together than the rest, suggesting that perhaps these two may correspond with one lobe of the normal.] DE LORIOL, *l. c.*, Pl. CXLIV. *fig.* 7.

664. **P. jurensis:** 6-sided stalk having two adjacent lobes *larger* than the others. *ibid.*, fig. 10.

The following is a case of *imperfect* change towards the six-rayed state:

665. **Sphærocrinus geometricus:** abnormal specimen having the basal plate irregularly six-sided by reason of the flattening of the external angle of an infra-basal piece. Three of the sides are normal and each of these bears a normal parabasal; but of the other three sides two are rather shorter than the normal sides and each of them bears a somewhat smaller parabasal. Upon the sixth side between these two, is a still smaller parabasal. The radials are five as usual, but one of them articulates with the smallest parabasal and in connexion with this its form is changed [for details see original figure]. Sculpture, &c. normal. ECK, H., *Verh. naturh. Ver. preuss. Rheinl.*, 1888, Ser. 5, v. p. 110, *fig.*

Three-rayed and five-rayed varieties of a four-rayed form.

*666. **Tetracrinus moniliformis:** normally 4-rayed (as shewn in Fig. 131, I.). A 3-rayed basal from the same locality, Birmensdorf (Fig. 131, II.). A 5-rayed basal from Oberbuchsitten (Fig. 131,

III.). DE LORIOL, P., *Mém. Soc. paléont. suisse*, 1877—1879, p. 245, Pl. XIX. figs. 39 *b*, 40 *a*, 41 *a*.

FIG. 131. I. Normal four-rayed basal of *Tetracrinus moniliformis* (from Birmensdorf). II. A three-rayed basal of the same species from the same locality as I. III. A five-rayed basal of the same species from Oberbuchsitten.
(After P. DE LORIOL.)

*667. **Cupressocrinus gracilis.** This form has normally a 5-rayed calyx, and a 5-sided basal plate containing only 4 canals round the central canal (Fig. 132, I.). Varieties have been seen in which

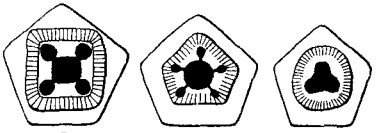

FIG. 132. *Cupressocrinus gracilis.* The normal form of the basal is shewn in I. A form with five canals round the central is represented in II, and in the specimen shewn in III there are three peripheral canals. See No. 667 *a*.
(After L. SCHULTZE.)

there are 5 (Fig. 132, II.), or 3 (Fig. 132, III.) such peripheral canals. The stalk is normally 4-sided, but in the varieties it is either 3- or 5-sided in correspondence with the number of canals.

667 *a*. **C. elongatus:** stalk may be either 4- or 5-sided. The species *C. inflatus* has *normally* 3 canals in the (circular) stalk. SCHULTZE, L., *Denkschr. Ak. Wiss., Math.-nat. Cl.*, 1867, XXVI. pp. 130 and 136, Pl. I. fig. 2 *b*, and Pl. III. figs. 2 *c* and 2 *i*. [Cp. No. 667.]

668. Abnormalities in the manner and frequency of branching in the arms of Crinoids leading to great numerical variation have been often recorded. See CARPENTER, *Chall. Rep.*, XXVI. Pt. LX. p. 28; *id. Phil. Trans.*, 1866, *Pt.* 2, p. 725 *Pl.*, also a case of *twelve* arms in **Antedon rosacea**, the abnormality not being symmetrical, DENDY, *Proc. R. Phys. Soc. Edin.*, IX. p. 180, Pl.; also case of **A. rosacea** having abnormal branches in two arms symmetrically placed with regard to the axis. BATESON, W., *P. Z. S.*, 1890, p. 584, fig. 4 (now in Coll. Surg. Mus.). The abnormal arms were b_2 and e_1 of the usual nomenclature, as shewn in Fig. 133. For details see original description.

*669. **Encrinus liliiformis:** amongst other abnormalities case given in which one of the radii bore *only one arm.* V. STROMBECK, *Palæont.*, IV. p. 169, Pl. XXXI. fig. 3.

ASTEROIDEA.

670. Symmetrical change in number of rays is common in some of the forms. **Asterias rubens** and **A. glacialis** are frequently seen with 6 or with 7 arms symmetrically arranged, and I have

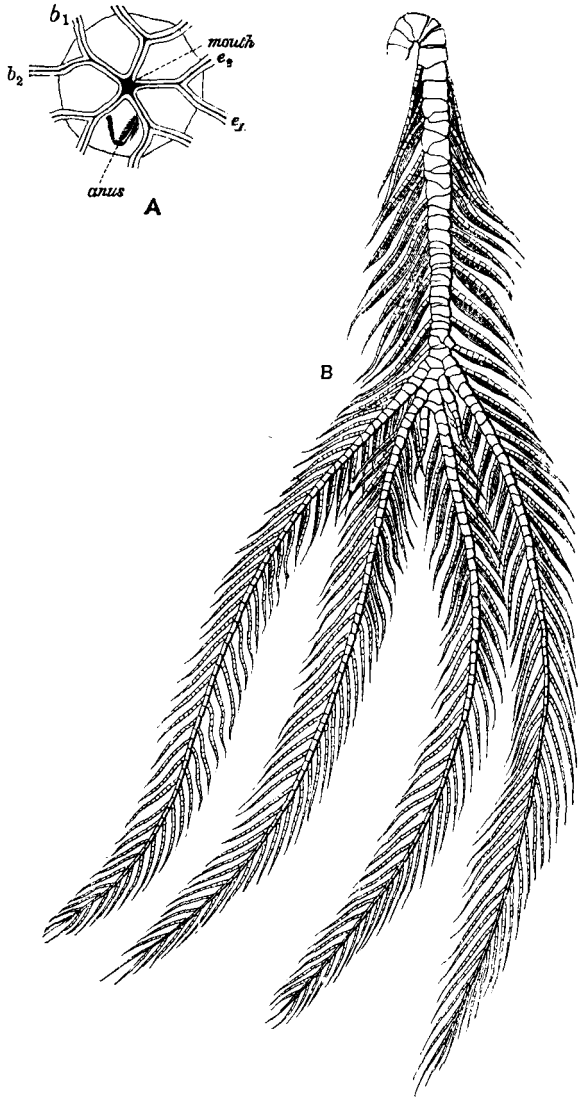

FIG. 133. *Antedon rosacea* having two arms abnormally divided. The figure A shews the relations of the two abnormal arms, b_2 and e_1, to the mouth and anus. B shews the arm b_2. (From *Proc. Zool. Soc.*)

seen one with 8. Individuals with 4 arms occur, but are much less common than those with 6. I have seen **Asterina gibbosa** with 4 rays, and a specimen (Scilly) given me by Mr S. F. Harmer has 6 rays, of which 2 are a little nearer together than the others (suggesting division of a ray). Mr E. W. MacBride tells me that he has seen several 6-rayed specimens of this species. Mr E. J. Bles kindly tells me that he dredged a 4-rayed **Porania pulvillus** in the Clyde estuary. There appeared to be no trace of a fifth ray and the specimen was as nearly as possible symmetrical.

The following cases exhibit special points.

671. **Asterias glacialis:** specimen with 8 rays possessed 3 madreporites. COUCH, J., *Charlesworth's Mag. of N. H.*, 1840, IV. p. 34.

672. **Asterias rubens:** 6-rayed specimens frequent at Wimereux. In several of these there are *two sand-canals* terminating at a common madreporite. GIARD, A., *Comptes rendus*, 1877, p. 973; cp. id. *C. R. soc. biol.*, 1888, p. 275.

673. *Partial division* of an arm is fairly common in Asteroids, but less common I believe than the total variation in number, though I know no statistics on this point. For a figure of **Asterias (Hippasterias) equestris** L. with a bifid arm, presenting no appearance as of regeneration see TIEDEMANN, *Zeitschr. f. Phys.*, 1831, IV. p. 123, Plate 1.

The two following are peculiar cases.

674. **Cribrella oculata:** one of the arms bearing a branch, not as a radius, but about (in dried specimen) at right angles to the normal arm, the property of Prof. C. STEWART, who kindly shewed it to me.

675. **Porania pulvillus,** Gray (a Starfish): Specimen 5 cm. in diameter, having five short rays. The ray opposite the madreporite *when viewed from the aboral surface* is seen to be distinctly bifurcated at

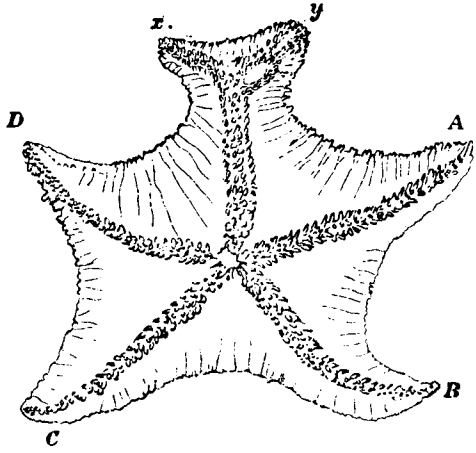

FIG. 134. *Porania pulvillus*, No. 675, having the arm opposite the madreporite abnormally divided as shewn at *x* and *y*. (From a sketch kindly sent by Prof. HERDMAN.)

about 1 cm. from its termination. The ambulacral groove of (Fig. 134) this abnormal ray divides into two branches at a distance of 2 cm. from the edge of the mouth. One of these branches runs along one of the forks of the ray to its extremity without further complication; but the other branch, belonging to the second fork, divides again 2 mm. from the first bifurcation, so as to form two tracts which unite with one another 3 mm. further on, thus inclosing a small piece of the ordinary integument in an ambulacral area. Finally, this ambulacral area divides once more close to the tip of the ray. There are no signs of injury or disease in the specimen. HERDMAN, W. A., *Nature*, 1886, XXXI. p. 596. [I am indebted to Professor Herdman for the accompanying diagram of this specimen.]

ECHINOIDEA.

In the Echinoids there are (1) cases of total Variation to a 4-rayed form with 4 ambulacra and 4 interambulacra[1]: (2) cases of partial or total disappearance of a definite ambulacrum or interambulacrum, which can be named either because part of it is present, or because two sets of similar plates thus become adjacent: (3) a case of total variation to a 6-rayed form: (4) cases of imperfect reduplication of a radius, thus forming an imperfectly 6-rayed form.

(1) *Total Variation to a 4-rayed form.*

676. **Cidarites coronatus?:** 4-rayed regular specimen (Fig. 135). MEYER, A. B., *Nova Acta C. L. C.*, XVIII. 1836, p. 289, Pl. XIII.

FIG. 135. *Cidarites coronatus?* No. 676, a regularly 4-rayed specimen from oral surface. (From A. B. Meyer.)

*677. **Echinoconus (Galerites) subrotundus:** 4-rayed specimen in Woodwardian Mus. (Fig. 136). The ambulacral and interambulacral areas are relatively wider than in a normal of the same size, the space of the areas that are wanting being as it were shared among those that are present. Apical disc roughly rectangular, and seems to be composed of 4 perforated basals (genitals) and 4 perforated radials (oculars). The basal plate corresponding to the posterior unpaired interambulacral area is perforated, though normally imperforate. Statement made that

[1] CUÉNOT, *Arch. de Biol.*, 1891, XI. p. 632, says that **Echinoconus vulgaris** has been seen with only *three* radii, but no authority is given.

the parts missing are those which lie on the left side of a line drawn through the middle of the anterior single ambulacrum and the posterior

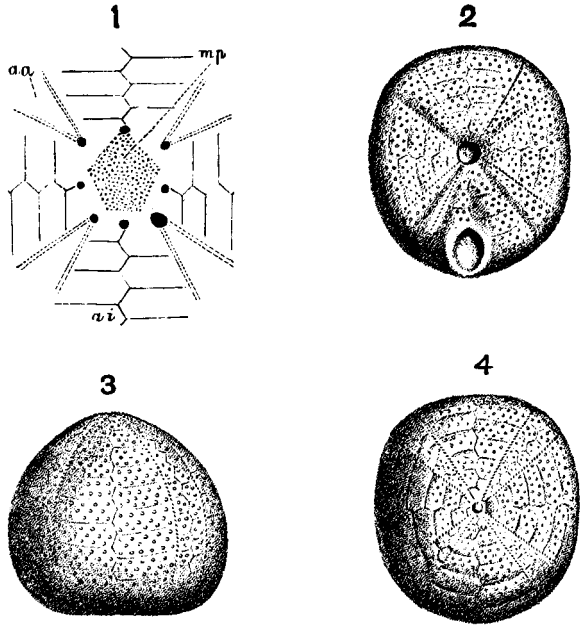

FIG. 136. *Echinoconus subrotundus* having 4 rays, No. 677. (From ROBERTS, *Geol. Mag.*, 1891.)
1. View of apical system. 2. Seen from side. 3. From apex. 4. From below. *aa*, anterior ambulacrum [?]. *mp*, madreporite. *ai*, anal interradius. The parts are lettered after Roberts.

unpaired interambulacrum, but it is not possible to say which of the paired areas of this side are wanting, as the pores in the ambulacral plates round the peristome are indistinctly shewn. ROBERTS, T., *Geol. Mag.*, 1891, Dec. III., VIII. p. 116, figs.

678. **Discoidea cylindrica:** a 4-rayed specimen, absolutely symmetrical. There are only 4 oculars corresponding with the 4 ambulacra. COTTEAU, G., *Pal. franç.*, 1862—67, VII. p. 31, Pl. 1011, figs. 6 and 7. [This is exactly like ROBERTS' case No. 677 and is illustrated by beautiful figures (*q.v.*). Cotteau in describing it says that the *anterior* ambulacrum is wanting. It is difficult to see any sufficient reason for the determination that this ambulacrum in particular is wanting. For in this case there are only 4 sets of interambulacral plates as well as 4 ambulacral areas in perfect symmetry. The anus of course lies between two ambulacra; and as the whole number is even and the radii are symmetrically arranged, there is thus no ambulacrum in the plane of the anus. Hence the suggestion that it is the anterior ambulacrum which is wanting. But if by Variation an Echinid has 4 symmetrical radii it would *always seem* that the

anterior ambulacrum was missing, whether it be the anterior ambulacrum, or the left anterior, or the left posterior that is wanting, or even if all 4 new ambulacra correspond with all 5 of the normal.]

679. **Amblypneustes** sp. (S. Australia): four specimens, each with four ambulacra [no description or statement as to symmetry]. HAACKE, *Zool. Anz.*, 1885, p. 505. (See No. 687.)

(2) *Partial or total disappearance of a definite ambulacrum or interambulacrum.*

*680. **Echinus melo**, having only four complete ambulacral areas (Fig. 137). The specimen is not spherical, for the apical system is warped over in one direction and the oral pole is pulled in an opposite direction, while the shell is much higher in the region of the apical system than it is at the opposite side. There are only four ocular plates, which are subequal, the madreporic plate and the plate opposite to it being somewhat larger than the other two. The genital plates are also four. Only four ambulacral areas leave the apical system, and at that point they are almost symmetrically disposed. Lower down however a triangular series of plates bearing ambulacral pores is intercalated between the plates of one of the interambulacral systems which it divides into two. This intercalated series is of course the representative of the ambulacral area which is wanting at the apex of the shell. The *five* ambulacra are nearly symmetrically disposed round the oral surface just as the *four* ambulacra are round the apical system. This transition from a tetramerous to a pentamerous symmetry is effected by complementary changes in the amount of divergence of the rays as they pass down the shell. Examination shews that the ambulacrum which is thus partially absent is the right posterior. PHILIPPI, *Arch. f. Naturg.*, III. p. 241, Plate.

*681. **Amblypneustes formosus:** a 4-rayed specimen having a somewhat asymmetrical test. One of the interambulacral regions is abnormally wide, and at about 9 plates down the side of the test in this region a wedge-shaped piece composed of several partially distinct plates bearing 7 pairs of ambulacral pores. This fragment doubtless represents the deficient ambulacral area. The apical system consists of 10 plates. The two genital plates of the abnormal area are reduced in size, and the ocular plate between them is abnormally large. Considering the madreporic plate as indicating the right anterior interambulacrum, it appears that it is the left anterior ambulacrum which is thus deficient. The height of the shell at the abnormal side is less than at the other. BELL, F. JEFFREY, *Jour. Linn. Soc.*, XV. p. 126, Plate.

In each of the foregoing the missing ambulacrum is actually at some place represented by plates of ambulacral character, and the shape of the test is greatly changed in correlation with the partial disappearance of the radius. The following cases differ, in that in them one ambulacrum is *wholly* wanting in the affected radius, and the interambulacra are contiguous with each other. Curiously enough in two of these specimens the symmetry is changed little or not at all. The cases in *Hemiaster* were all Algerian fossils [1].

[1] Besides those here given in the text, GAUTHIER in the same place describes an interesting case of symmetrical reduction in the two posterior ambulacra of **Hemiaster africanus**.

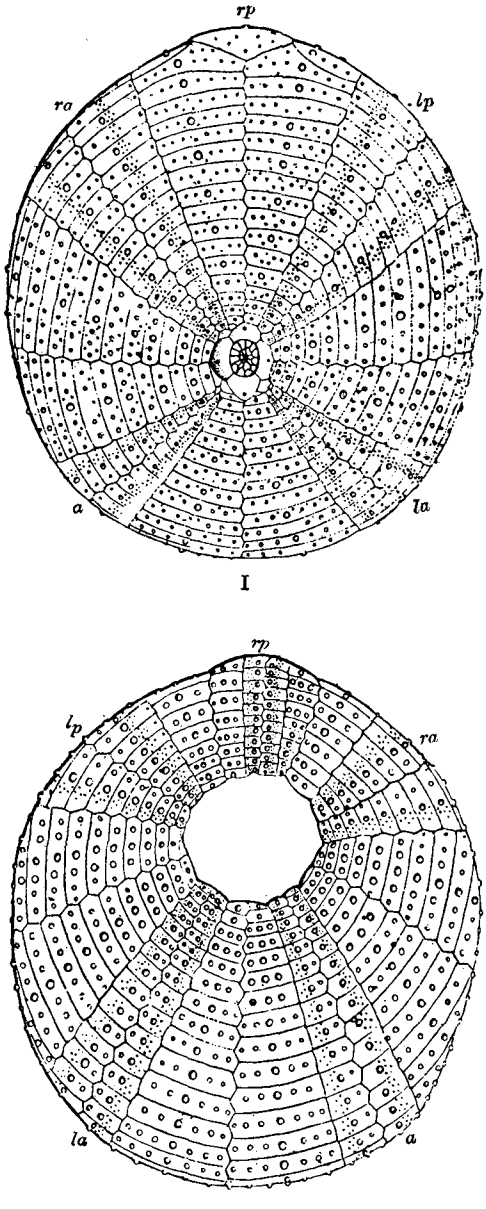

FIG. 137. *Echinus melo*, No. 680, having the right posterior ambulacrum partially absent. *a*, anterior ambulacrum. *ra*, *la*, right and left anterior ambulacra. *rp*, *lp*, right and left posterior ambulacra. I. View from apex. II. View from oral surface. (From PHILIPPI.)

682. **Hemiaster batnensis:** specimen in which the *left posterior* ambulacrum is not present, and the ambulacral groove is only indicated by a shallow depression, beyond which there are some rounded pores which continue the ambulacral area beyond the fasciole. The corresponding ocular seems to be absent. The test is of normal form, but the median suture of the right posterior interambulacrum is not quite straight. GAUTHIER, M. V., *Comptes rendus de l'Ass. pour l'av. des sci.*, 1885, XIII. p. 258, Pl. VII. fig. 1.

683. **H. batnensis:** very similar case of absence of right anterior ambulacrum and corresponding genital and ocular plate. *ibid.*, fig. 3.

684. **Hemiaster** sp.: left anterior ambulacrum wanting and is gone without trace. There are only 4 oculars and 3 genitals. In correspondence with this variation there is considerable change in symmetry of the test, which is irregular, the anterior and right anterior ambulacra being deflected from their normal courses. [See details.] *Ibid.*, figs. 4 and 4 *bis*. [Here, where there is a clear differentiation between the several ambulacra, it is doubtless possible to affirm that such a definite ambulacrum is missing, for the two interambulacra are left adjacent to each other.]

685. **Echinus sphæra** (O. F. Müller): specimen described in which the *left posterior interambulacral* series of plates is almost entirely absent. The details of the structure are as follows: the genital plate which stands at the head of the left posterior interambulacrum is reduced in size in all directions; but the two ocular plates which should be separated by it are somewhat enlarged, bearing several extra tubercles, and meet together peripherally to the genital plate. The series of interambulacral plates which should begin from this genital plate are represented by a rudimentary row of small tubercles: the ambulacral systems which are normally separated by these plates are consequently almost contiguous. The rudimentary interambulacral series widens somewhat at a short distance from the apical series and forms a small island of interambulacral structure bearing 4 large tubercles. Beyond this, viz. at a point placed about $\frac{1}{3}$ the distance from the apex to the oral surface, the two ambulacra again unite and are continued as a single ambulacrum of double width. DÖNITZ, W., *Müller's Arch. f. Anat. u. Phys.*, 1866, p. 406, Pl. XI.

(3) *Case of total Variation to a 6-rayed form.*

*686. **Galerites albogalerus(?)**: a regularly 6-rayed specimen having six symmetrical ambulacra and interambulacra (Fig. 138). MEYER, A. B., *Nova Acta Ac. Cæs. Leop. Car.*, XVIII. 1836, p. 224, Pl. XIII.

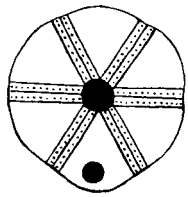

FIG. 138. *Galerites albogalerus*, No. 686. A six-rayed specimen. (After MEYER.)

687. **Amblypneustes** (S. Australia): 6-rayed specimen [no description or statement as to symmetry]. HAACKE, W., *Zool. Anz.*, 1885, p. 505. (See No. 679.)

(4) *Cases of imperfect reduplication of a radius.*

*688. **Amblypneustes griseus:** having one of the ambulacra doubled (Fig. 139); the apical system was normal. The width of the anterior ambulacral region was almost double that of the others: it contained two ambulacra lying side by side, each, as usual, composed of a double row of plates with an ambulacral area and two poriferous zones. The

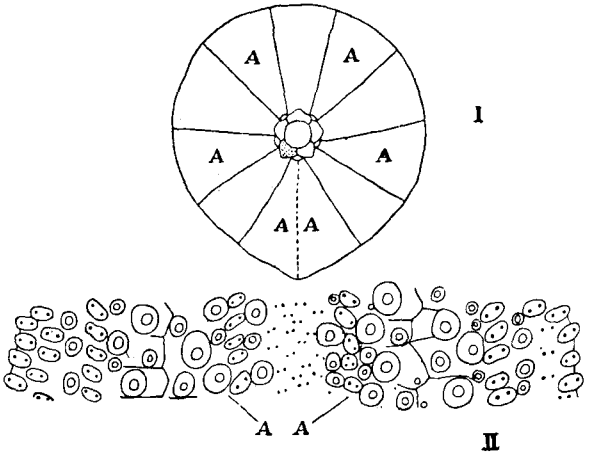

FIG. 139. *Amblypneustes griseus*, No. 688. Specimen having the anterior ambulacrum doubled. I. The test seen from the apex. II. Details of anterior ambulacrum shewing combined poriferous zones between *A* and *A*. The dotted line bisects the ambulacrum of double width. (After STEWART.)

areas and external poriferous zones are like those of a normal ambulacrum; but the poriferous zones which touch one another are fused together, with the pores irregularly arranged. The combined poriferous zones are not quite equal to the sum of two normal ones. The whole of this area, formed of the union of two ambulacra, projects as a ridge which is continued down the whole of the side of the shell. STEWART, C., *Jour. Linn. Soc.*, XV. p. 130, Pl.

689. **Hemiaster latigrunda:** right posterior ambulacrum double, the two resulting ambulacra are closely adjacent peripherally and a small interambulacral area is formed between them in their more central parts. There are 6 oculars but no extra genital. GAUTHIER, *l. c.*, figs. 5 and 5 *bis*.

690. **Hemiaster batnensis:** right anterior ambulacrum double, the two ambulacra are in contact through all their length. COTTEAU, *Pal. franç.*, 1869, p. 150, Pl. XX., and GAUTHIER, *l. c.*

[For interesting evidence as to variation in the number of *genital pores* on the costals in several genera of Echini, see LAMBERT, *Bull. Soc. Yonne*, 1890, XLIV. *Sci.*

nat., p. 34; also GAUTHIER, *Comptes rendus Ass. fr. pour l'av. Sci.*, Toulouse, 1887, and other references given by these authors.]

OPHIUROIDEA.

Individuals with various numbers of arms are often seen, especially in the genera *Ophiothela*, *Ophiocoma*, *Ophiacantha* and *Ophiactis*, and in many of the species there are most usually six arms. In these forms the evidence as to Meristic Variation is complicated by the circumstance that in several of them change in the number of arms may take place in the ontogeny, by division and subsequent regeneration (see note on p. 433).