Monticuliporoidea (concluded).—Echinodermata.

MONTICULIPORA.

sub-genus A.

Dekayia Edw. & Haime, 1851.


Remarks.—This sub-genus can only be separated from Monticulipora proper by the surface columns, which constitute a marked feature of the exterior. Mr. Ulrich's Dekayella can not be regarded as distinct. In his latest publication (Pal. of Minnesota, vol. 3 of Geol. and Nat. Hist. Survey, 1893, p. 269) he gives in substance the following description: Corallum ramose; branches cylindrical or compressed; calices angular or rounded, their shape depending upon the number and disposition of the interstitial corallites; these are more or less numerous among the larger calices and aggregated into irregular clusters, or they may be wanting except in the clusters or even absent nearly altogether; spiniform tubuli of all sizes, the larger ones commencing in the axial region, the smaller ones more abundant and developed in the peripheral region only; tabulae horizontal, numerous.

In his remarks upon the genus Mr. Ulrich states that it might be well to unite Dekayia, Dekayella and Heterotrypa (as restricted by him) into one, for the reason that there are so many intermediate forms. He eventually concludes, however, to keep them distinct.
Quite a number of species have been described from our group, but they do not seem to be founded upon very good characters. Those that seem worthy of specific rank are given below.

78.—M. (Decayia) aspera. Edw. & Haime, 1851.

Corallum dendroid, branching frequently and dichotomously and arising from a broad basal expansion; branches varying from two to eight lines in diameter according as they are near the top or at the base of the corallum; surface usually with low and rounded monticules, four or five in about one-half inch; formed of cells very little larger than the average and often with a limited number of smaller interstitial cells; spines conspicuous with thick walls and small cavity occupying angles of cells; corallites polygonal; tabulae wanting in the axial region and remote in the peripheral. (Pol. Foss. des Terr. Pal., 1851, p. 277. Ulrich, Jour. Cin. Soc. Nat. Hist., vol. 6, 1883, p. 149.) (Cheetes attritus Nich., Quar. Jour. Geol. Soc. Lond., vol. 30, 1874, p. 503: Decayia multispinosa Ulrich, Ibidem, p. 154.)

Locality.—Cincinnati.

Remarks.—In a previous paper several other synonyms were given for this species.* While the species is a variable one it has been deemed best in the present instance to increase the number of species, perhaps unwisely. All seem to agree that Nicholson's attrita is the same as D. aspera, and D. multispinosa differs mainly in a larger number of surface spines. Internally the structure of the two is the same.

79.—M. (Decayia) maculata James, 1881.

Fig. 11.—M. (Decayia) maculata James: a, specimen nat. size; b, surface x 18; c, tangential section, x 18; d, longitudinal section, x 18. (After an unpublished plate by Ulrich.)

Corallum dendroid, branches cylindrical or sub-cylindrical two to four or more lines in diameter, branching dichotomously; surface with conspicuous, rounded elevations or monticules, occupied by cells much smaller than the average; calices irregular in form, circular or polygonal, varying in size; interstitial tubes occasionally present; spines, at angles of the cells, conspicuous: walls of corallites thin, internal structure unknown. (The Paleontologist, No. 5, June, 1881, p. 36.)

Locality.—Loveland, O.

Remarks.—This form seems mainly distinguishable by the groups of cells smaller than the average. Although previously placed as one of the synonyms of the preceding, it seems to possess characters sufficient to permit its being considered a distinct species.

So.—M. (Dekayia) pelliculata Ulrich, 1883.

Corallum dendroid, with smooth, thick, rounded or flattened branches, arising from a broad base, varying in diameter from three lines to one inch; surface smooth but often with clusters of cells slightly larger than the average, with small aggregations of much smaller cells; surface also frequently covered with a thin pellicle; spines prominent; calices angular; corallites with very thin walls in the axial region, which become thickened toward the surface; tabulae few in the axial region but more numerous in the peripheral. (Jour. Cin. Soc. Nat. Hist., vol. 6, 1883, p. 150.) (Dekayia appressa Ulr. Ibid, p. 152; D. paupera Ulr. Ibid, p. 153.)

Locality.—Cincinnati.

Remarks.—There does not seem to be any good characters by which the forms described as appressa and paupera can be separated from pelliculata. They are more varietal than specific.

Sub-genus B.

Constellaria Dana, 1846.

Corallum dendroid or incrusting, with the branches cylindrical, flattened, or more or less frondose; surface with more or less conspicuous star-shaped, depressed maculae made up of small tubes surrounded by a variable number of (8 to 20) ridges, radiating outward and carrying large tubes; occasionally nearly smooth; calices oval or circular, with thick walls; corallites of two kinds, the larger circular or oval, with well developed walls which are thickened as the surface is
approached; tabulae few and chiefly developed in the outer portions; small corallites developed at the angles of junction of the larger ones, especially in the depressed centres of closely disposed stellate areas which project above the surface as star-shaped elevations; walls of the small corallites imperfectly developed; these corallites angular or sub-angular, with numerous tabulae which are sometimes sub-vesicular. (Explor. Exped., Zoophytes, 1846, p. 537. Nicholson, Pal. Tab. Corals, 1879, pp. 292, 300; Ibid., Genus Montic., 1881, p. 97.) (Stellipora Hall, Pal. of New York, vol. 1, 1847, p. 79.)

81.—M. (CONSTELLARIA) POLYSTOMELLA Nicholson, 1875.

Corallum forming palmate or sub-lobate, flattened expansions, or cylindrical stems, varying in height and thickness: generally from one and one-half lines to two lines thick, and composed of corallites radiating from an imaginary central plane in all directions to the surface; the surface with numerous stellate areas, one line apart, consisting of a depressed central space, surrounded by from six to fourteen or more prominent and radiating ridges; corallites of two kinds: the larger oval or circular, occupying the general surface of the corallum, and found especially on the ridges of the star-shaped monticules: smaller ones occupying inter-spaces between the larger ones, and especially the central depressed areas; tubes thin-walled; tabulae complete and horizontal, few or absent in the axial regions, but increasing in number toward the peripheral region, and at the surface crowded close together. (Pal. of Ohio, vol. 2, 1875, p. 215.) Constellaria antheloidea Nich. Ibid, p. 214 non Hall; C. florida Ulrich, Jour. Cin. Soc. Nat. Hist., vol. 6, 1883, p. 267: C. limitaris Ulr. Ibid, p. 269: C. fischeri Ulr. Ibid, p. 270: Stellipora limitaris Ulr. Ibid, vol. 2, 1879, p. 126.)

Locality.—Cincinnati and numerous places in the vicinity; Mt. Sterling, Ky., Tennessee, Canada, Wisconsin, etc.

Remarks.—This is a variable and wide-spread species, ranging from the Trenton through the whole of the Cincinnati group. Various attempts have been made to separate forms as species or varieties, but not, to our belief, with any success. Attention should be called to the fact that the species under consideration has been called C. antheloidea Hall. It is an error, since this species is parasitic, while poly stomella is ramose or frondescent; it is also a Trenton form occurring in New York. It may, however, yet be found in our region.
82.—M. (constellaria) parva Ulrich, 1890.

Corallum irregularly undulating or frondose, 2 to 3 mm. thick, 2.5 mm. or more high, from a broad base: surface smooth, with star-shaped maculae from 1 to 1.5 mm. apart, about 60 in 10 mm. square: walls of corallites thin throughout, ringlike in the mature region, bending rather abruptly from the axial to the peripheral region; about 0.08 mm. in diameter between the stars, the 2 to 6 cells between the rays of the maculae about 0.13 mm. in diameter: calices circular with a peristome: interstitial cells angular, thin-walled, arranged in star-shaped maculae, and in the intermediate spaces surrounding the corallites in 1 or 2 series: tabulae from one-half to one tube-diameter apart in the peripheral region, and from 1 to 2 diameters apart in the axial region: very crowded in the interstitial cells. (Geol. Sur. Ills., vol. 8, 1890, p. 425.)

Locality.—Wilmington, Ills.

Sub-genus C.

Fistulipora McCoy, 1849.

Corallum ramose or incrusting: corallites of two kinds, larger ones oval or circular, with few and remote tabulae, with well-developed walls, not thickened toward the surface; often with oblique calices, surrounded by small, interstitial cells in one or two rows, the apertures generally angular; tabulae in these corallites numerous, sometimes vesicular, by imperfection of the walls of the neighboring corallites; maculae, if present, generally made up of smaller cells than the average, never elevated above the surface, or surrounded by radiating ridges as in Constellaria; interstitial cells often closed by a thin, calcareous membrane: walls of calices generally thin. (Ann. & Mag. Nat. Hist., 2d ser. vol. 3, 1849, p. 130. Nicholson, Pal. Tab. Corals, 1879, pp. 292, 304.) (Callopora Hall, Pal. of N. Y., vol. 2, 1852, p. 144.)

83.—M. (fistulipora) Oweni James, 1884.

Corallum in flat, twisted expansions, one-half to one line thick; sometimes lobate, or in sub-cylindrical, hollow tubes: surface with clusters of eight or ten projecting apertures in each line, sometimes regularly and again irregularly arranged maculae about one line apart and about one-half a line across; sometimes depressed, the interstitial
spaces occupied by small pores: corallites arising from a delicate, striated epitheca; calices sub-oval or sub-circular: walls thin, but thicker on one side than on the other: tubes slightly curved at the base, then vertical to the surface, sub-oval or sub-circular: obscure horizontal tabulae, with a few vesicular attachments to the walls. (Jour. Cin. Soc. Nat. Hist., vol. 7, 1884, p. 21.) (Diamesopora oweni Ulrich, Geol. Sur. Illinois, vol. 8, 1890, p. 467.)

84.—M. (Fistulipora) rustica Ulrich (sp.) 1893.

Corallum irregularly ramose, branches 5 to 10 mm. in diameter: surface with low, rounded eminences, occasionally, rough under a lens: the spini-form corallites numerous but not inflecting the walls of the corallites; apertures or calices rounded, 11 in 3 mm.; interstitial cells abundant, unequal, "rounded at the surface:" tangential sections just below the surface show the corallites to be rounded, with moderately thick walls: interstitial cells sharply defined, sub-angular, unequal, three or four to each corallite: spiniform tubuli strong, two to each corallite: mainly in the walls, which are occasionally bent inward; at a deeper level, the walls are thinner: tabulae abundant in all of the tubes, mainly horizontal in the axial, but vesicular in the peripheral region. (Pal. of Minn., vol. 3 of Geol. and Nat. Hist. Survey, 1893, p. 234 as Homotrypella rustica.

Locality.—Various places in Ohio, Indiana and Minnesota.

85.—M. (Fistulipora) granulifera (Ulrich) 1879.

Corallum ramose with sub-cylindrical branches, dividing dichotomously at varying distances, sometimes irregularly thickened or nodulated and having a diameter of from two to five lines: surface smooth or with obscure tubercles or macule: in the former case composed of tubes slightly larger than the average and in the latter of minute tubuli: calices unequal, varying from circular or oval to sub-polygonal: intercellular spaces thick and with numerous small corallites, in unworn specimens appearing like spines, but in worn examples showing a tubular character: tabulae few in the axial region but becoming more numerous toward the surface: walls thin. (Jour. Cin. Soc. Nat. Hist., vol. 2, 1879, p. 128 as Chatetes: Homotrypella granulifera Ulr., 14th Rept. Geol. and Nat. Hist. Sur. of Minn., 1886, p. 83.)
Locality.—Frankfort, Bergen, etc., Kentucky.

Remarks.—This was in the paper on Monticuliporoids placed as a synonym of *M. (F.) venusta*, but further consideration indicates that this is more likely a polyzoan than a coral and it will be described under that group.

86.—*M. (Fistulipora) nicholsoni* James, 1875.

![Various figures showing variation: a, b, c M. nicholsoni (typical); b and c showing surface features, enlarged but at different points on the same corallum; d, e, f, g and h views of *F. siluriana* James; g and h views of surface, enlarged, from different points on same corallum; i surface features, enlarged, of corallum described as *F. (?) multipora*. (Original.)
Corallum incrusting, or forming more or less branching or frondose masses: surface smooth: calices in perfect specimens slightly oblique, or arched, with raised and very thin margins; in slightly worn specimens calices circular or oval, often with a ring-like margin and surrounded by one or two rows of polygonal interstitial cells: in specimens still more worn the cell apertures have thicker walls and interstitial cells are ill-defined. (Cat. Foss. Cin. Group, 1875, p. 3, as Ceramopora.) (Fistulipora? multipora James. The Paleont., 1878, p. 2; F. siluriana James, Ibid, 1879, p. 19; F. flabellata Ulrich, Jour. Cin. Soc. Nat. Hist., vol. 2, 1879, p. 28.)

Locality.—Cincinnati.

Remarks.—The names cited as synonyms above are believed to have been given because of the various aspects a single species presents under different conditions. A single specimen will sometimes show in one position the arched, thin-walled apertures: in another the ring-like, circular aperture with numerous interstitial cells, and in still another place an absence of interstitial cells, It has been mainly upon these features that the above names have been given. What was described as F. siluriana was a worn state with thick intercellular spaces: flabellata is a less worn condition with numerous interstitial cells: and multipora is still less worn with a smaller number of irregularly shaped interstitial cells.

87.—M. (Fistulipora) Milfordensis James, 1878.

Corallum incrusting, generally growing on crinoid stems, and \( \frac{1}{8} \) to \( \frac{1}{2} \) a line thick: surface smooth: calices oval or sub-polygonal, not arranged in any regular order: walls of calices elevated, sometimes in contact with neighboring calices, and sometimes separated: in the latter case the intercellular spaces with many small, irregular calices. (The Paleont., No. 2, Sept., 1878, p. 11 as Calllopora.)

Locality.—Hamilton and Clermont counties.

Since the first portion of this paper was published the following species has come to light. The description was found among the papers of Mr. U. P. James, and the specimen was in his collection. This is now in the Chicago University. The illustrations were made from the type specimen. It is believed to be sufficiently distinct from all described species to warrant a name.
Fig. 13.—Monticulipora subcylindrica, U. P. James, n. sp., in MS. a type specimen, half nat. size; b longitudinal section, magnified; c surface, magnified. (Original.)

Corallum irregularly sub-cylindrical, about four and one-half inches long, by one to one and one half inches in diameter, tapering gradually to both ends where it rounds off abruptly: surface with distinct monticules irregularly distributed, about one or one and one-half lines apart and extending even over the ends; calices polygonal, eight or ten in one line, those on the monticules slightly larger than the average; tube walls thin and sharp when unworn; no interstitial coralites: corallites radiating from a central point or a central object directly to the surface, with wavy walls; tabulae numerous, complete and horizontal, apparently as numerous at the centre as at the periphery.

Locality.—Cincinnati and Morrow, Ohio.

Remarks.—This description is drawn up from notes left by Mr. James and from the specimen labeled by him. It seems to be a good species and to be well characterized by its mode of growth, the uniform cells, and the close tabulation. The specimen was named in 1887, apparently at the time it was found, but the description has never before been published.

INCERTA SEDES.

A few species have been described as belonging to this group that are too indefinite to have any place assigned to them,
and a few remarks will here be made relative to them. One species, also here noticed, belongs, perhaps, in Group 1 (Massive species) while another, probably referable here, was originally described as a sea-weed.

*Homotrypa obliqua* Ulrich, (Jour. Cin. Soc. Nat. Hist., vol. 5, 1882, p. 243) was described as dendroid with cylindrical or compressed branches; surface with numerous conspicuous monticules, or else smooth; cells polygonal; apertures more or less oblique; tabulae wanting in the axial region, but both straight and vesicular in the peripheral; connecting foramina are shown in tangential sections. This last feature renders this species anomalous and apparently throws it out of the Monticuliporoids. It occurs near Cincinnati.

*Petigopora gregaria* Ulrich, (Jour. Cin. Soc. Nat. Hist., vol. 6, 1883, p. 155) was described as parasitic, the corallum consisting of patches from one to three lines in diameter and one-fourth of a line thick; a narrow smooth or wrinkled membrane forms the outer margin, which is slightly elevated; surface smooth; apertures equal; no interstitial cells; spiniform corallites inconspicuous; walls thin and flexuous; tabulae apparently wanting. It occurs at Cincinnati.

*Monticulipora hospitalis* var. *neglecta* James and James, was briefly described in the paper on Monticuliporoids, (Jour. Cin. Soc. Nat. Hist., vol. 11, 1888, p. 27.) In the absence of the type specimen it is impossible to give any other details than those there given. This description is as follows: “Corallum irregularly conical: surface with many prominent monticules about one line apart: calices equal in size, sub-polygonal: corallites take a direct course from base to apex.”

A species described by Mr. E. O. Ulrich under the name of *Monotrypa rectimuralis* (Geol. Sur. of Illinois, vol. 8, 1890, p. 462) is similar in many respects to *M. undulata* Nicholson. Mr. Ulrich's species is described as massive, varying from lenticular to subspherical about four inches or more (10 cm.) in diameter; calices polygonal; surface generally smooth but occasionally with faintly elevated clusters of cells about one-half larger than the rest: corallites direct, with very thin straight walls, angular; tabulae few, complete and horizontal; no spiniform corallites.

He records this species as occurring at Cincinnati and in Illinois.
Dystactophycus mamillanum Miller and Dyer (Contri. to Pal. No. 2, July, 1878, p. 2), is a name given to what was supposed to be a sea-weed. It was described as mammiform or depressed conical, from eight to twelve inches in diameter and from one and one-half to four inches in height in the center. This "frond" was marked with concentric rings, twelve to eighteen in an inch. It presents no other characters, and it most likely represents an impression made by the epitecal membrane of the base of a large species of Monticulipora.

ECHINODERMATA.

This sub-kingdom includes the well-known sea-urchins, sea-cucumbers, sea-lilies, star fishes, etc. It contains a vast number of living genera and species, and was well developed in some of its classes far back in Paleozoic time. Its features are given by Dr. Nicholson as follows: *

"Simple marine organisms, which are mostly bilaterally symmetrical when young, but which in the adult condition have this bilateral symmetry more or less extensively masked by a radial (usually pentamerous) arrangement of their parts. An alimentary canal is present with or without a distinct anus, separate from the proper body cavity. A system of water vessels often communicating directly with the exterior, and generally connected with protrusible tubes (feet) is present. The nervous system is radiate, consisting of an cesophageal ring, and radiating branches. The integument is characteristically hard-ened by the deposition in it of carbonate of lime in the form of plates, granules, or spicules."

The sub-kingdom has been divided into two great divisions based on the absence or presence of a stalk. To the former belong the sea-urchins, the star-fishes, etc., and to the latter the crinoids. There is a further division into classes, and then into orders and families. In the present instance we shall disregard the two latter, inasmuch as it frequently occurs that single genera give their names to families; and the number of genera is not sufficient to justify in this place so minute a subdivision. The following classes are those found in the Cincinnati Group.

Division A.—Echinozoa. *

Class I.—Asteroidea.

Here belong the star-fishes, whose characters may be given as follows:

Body star-shaped or pentagonal, consisting of a central disk, surrounded by five or more lobes or rays which radiate from the body, are hollow and contain prolongations of the viscera; integument coriaceous and strengthened by irregular calcareous plates, or studded with spines; dental apparatus none; mouth inferior and central; anus absent, or, if present, dorsal; ambulacral tube-feet protruded from grooves on the under surface of the rays.†

SYNOPSIS OF GENERA.

1.—Palæaster Hall. Disc present: ambulacral grooves deep, either wide or narrow; oval plates five or ten; two rows of plates on each side of groove, one adambulacral and one marginal row; three or more rows above.

2.—Petraster Billings. Disc present: ambularcal groove narrow; an incomplete series of plates between the adambulacral and marginal plates.

3.—Palasterina McCoy. Disc present: ambulacral grooves shallow; oral plates ten; marginal plates lacking, and only one row of adambulacral plates.

4.—Stenaster Billings. Disc absent: ambulacral grooves shallow; oral plates ten; adambulacral plates in one row, the marginal plates absent.

Genus I.—Palæaster Hall, 1852.

Body stellate; rays five, occasionally seven, spinous, composed of five or more series of plates, generally two ambulacral, two adambulacral (one on each side of the ambulacral groove), and two

* Forms without a stalk.
marginal; ambulacral grooves deep, wide or narrow, and bordered by strong spines; pores penetrating the plates of the upper surface. (Pal. of New York, vol. 2, p. 247.)

**Remarks.**—This genus is represented by quite a number of species in our section. An effort was made to arrange them in some sort of scheme by which their identification could be facilitated. Owing to the fact that in many cases only imperfect specimens are known, or else only the dorsal or ventral surface is known, and to the fact that the descriptions given by various authors do not always mention similar characters, this has been impossible. All that has been attempted, therefore, is to group the species according as the ambulacral groove is wide or narrow. In two cases the ventral side is unknown, so that these have been placed by themselves.

**A.**—**Ambulacral grooves wide.**

1.—**P. JAMESII** Dana, 1863.

Pentagonal; rays five, about two inches long from center of disc; body about one and one-quarter inches in diameter; marginal plates probably from twenty to fifty alternating with the adambulacral plates, which are about three times as wide as long; flat at the outer ends and raised into a conspicuous elevation near the ambulacral furrow, apparently about twenty-five in number, the inner edges interlocking in a peculiar manner; ambulacral groove wide: oral plates ten, in five pairs, each irregular in form, longer than wide, flattened and depressed at their outer ends; elevated into crest-like prominences farther in, and with a lateral process or thickening on the outer side of each; dorsal surface unknown. (Am. Jour. of Sciences, 2d ser., vol. 35, p. 265, as *Palaeasterina?*: Pal. of Ohio, vol. 1, p. 62.)

**Locality.**—Cincinnati, O.

**Remarks.**—This species has attained notoriety by being figured in Dana's Manual of Geology and other places. It is one of the largest species of the genus and is well characterized and easily separable from all other species by the peculiar form of the oral plates. The type specimen is in the Walker Museum of Chicago University.

2.—**P. MAGNIFICUS** S. A. Miller, 1884.

Pentagonal: rays (if perfect) about two and three-eighth inches long; disc one and one-quarter inches in diameter; marginal plates
hexagonal, each with several small pits for articulation of spines; ambulacral groove wide; ambulacral plates in two rows, about fifty in each row, with their greatest diameter across the rows; adambulacral plates also fifty in number, hexagonal, much wider than long, more numerous than the marginal plates, alternating with them near the ends of rays, and having pits for articulation of spines; dorsal surface covered in part with convex, spine-bearing plates, generally a single spine to each plate; a single series of highly convex plates down the centre of each ray, and one on either side, the spaces between filled with smaller plates so arranged as to run diagonally from the side to the central row, and forming an angle with each plate in the central series. (Jour. Cin. Soc. Nat. Hist., vol. 7, p. 16.)

Locality.—Waynesville, Ohio.

3. — P. Dyeri Meek, 1872.

Pentagonal; rays and body large, the former probably one and one-half inches long; body about two inches in diameter; marginal plates small, tumid, nearly square, alternating with a row of similar but slightly smaller adambulacral plates, the number in each series being about the same; both series roughened by course granules and possessing a pit for the insertion of a spine; spines smooth, straight, rounded, thickened at the attached end and tapering to a blunt point; ambulacral groove wide; dorsal side of disc and rays composed of numerous small pieces, with large pores between them, touching at three or four salient points, and thus forming a reticulated structure; each piece with a central tubercle having a minute pit for the insertion of a small, short spine; madreporiform tubercle flat, obtusely subtrilobate, with striations like the nervation of some ferns. (Am. Jour. Science, 3d ser., vol. 3, p. 257; Pal. of Ohio, vol. 1, p. 58.)

Locality.—Cincinnati, Ohio.

4. — P. Granulosus Hall, 1866.

Pentagonal; rays five, a little more than twice as long as their breadth at the base, obtuse; body medium size; marginal plates small, tuberculose, about twenty-five on each side of a ray one and one-quarter inches long; ambulacral grooves broad, with two series of ambulacral plates slightly curved, each marked by an elevated ridge along its entire breadth; adambulacral plates smaller than the mar-
ginal ones, forty-two or forty-three in number, the basal ones (oral) ten, in pairs, small, elongated, subtriangular; upper surface of rays with numerous small, tuberculose or sub-spinoose plates; madreporiform tubercle large, situated laterally at the base of two rays. (Rept. N. Y. State Mus. Nat. Hist., 1866, p. 285: 20th Rept. N. Y. State Mus. 1870, p. 327.)

Locality.—Cincinnati, O.

5.—P. exculptus S. A. Miller, 1881.

Pentagonal; diameter of body about 0.9 of an inch; rays a little longer; breadth of ray at body about three-fifths of an inch, obtusely pointed: marginal plates somewhat quadrangular, the first eight occupying about one-half inch; eighteen in one inch, and about twenty-five on each side of each ray; surface tuberculated and probably spinous; adambulacral plates about twenty-eight, narrower than, but about the same length as the marginal ones, spinous; a single somewhat pentagonal plate between the junction of marginal plates and of each ray; ambulacral furrow wide; each plate with a sharp ridge, increasing in height as it approaches the adambulacral row of plates. (Jour. Cin. Soc. Nat. Hist., vol. 6, p. 69.)

Locality.—Waynesville, O.

6.—P. miamiensis S. A. Miller, 1885.

Pentagonal; rays 0.9 inch long; diameter of body 0.6 inch; rays obtuse; marginal plates wider than long, about twelve in one-half inch from body, with two at junction of rays; ambulacral groove wide: ambulacral plates eighteen in one-half inch, each with an angular ridge; adambulacral plates about same size as marginal ones, and alternating with them, as shown by the figure, no mention being made in the description. (Jour. Cin. Soc. Nat. Hist., vol. 3, p. 143.)

Locality.—Waynesville, O.

7.—P. spinulosus Miller and Dyer, 1878.

Body pentagonal; rays longer than diameter of body; marginal plates globular near ends of rays, but lengthened toward the bases, six measuring three lines; junction of marginal plates with body formed by two wedge-shaped plates; ambulacral groove deep and wide; ambulacral plates with their greatest length across the rays,
and with a sharp ridge in the middle; adambulacral plates a little smaller than the marginal, and with two or three spines to each, tapering to a point, and longer than the diameter of the plate; dorsal surface with irregularly-sized and strongly tuberculated or spinous plates; madreporiform tubercle an oblate spheroid, depressed and marked with fine radiating striæ. (Jour. Cin. Soc. Nat. Hist., vol. 1, p. 32.)

**Locality.**—Cincinnati.

8.—P. DUBIUS Miller and Dyer, 1878.

Pentagonal; rays longer than diameter of body, tapering to apex; body three-tenth inches in diameter; marginal plates unknown; ambulacral groove deep, angular, formed by two series of plates; each plate three times as long as wide, and fifteen plates in one-quarter inch on each side of each ray; adambulacral or oral plates and madreporiform tubercle unknown. (Contri. to Paleont., No. 2, p. 5.)

**Locality.**—Cincinnati, Ohio.

9.—P. FINEI Ulrich, 1879.

Pentagonal, small; rays 0.3 inch long, rather broad, pointed, expanded about midway between the body and the point; marginal plates on dorsal surface twelve to fourteen, each with a pit for the articulation of a spine; on ventral surface convex, twelve, with a piece at junction of rays three times as large as any other, sub-circular and very convex; ambulacral plates with a sharp ridge, not alternating with adambulacral plates, which are nine to ten in number; dorsal surface of rays with four rows of plates, twelve to fourteen in each row, increasing in size toward the disc, which is composed of irregularly shaped and prominent pieces; madreporiform tubercle small, circular, very prominent and marked by strong striæ, which become more numerous toward the margin by intercalation of other striæ; rays sometimes only four. (Jour. Cin. Soc. Nat. Hist., vol. 2, p. 19.)

**Locality.**—Cincinnati, O.

10.—P. ANTIQUATA (Locke) sp., 1846.

Rays five, each about one and one-half inches long; marginal plates rounded; two rows of adambulacral plates at base of rays and
only one row at apex; ambulacral groove wide; ambulacral plates unknown. (Jour. Phil. Acad. Nat. Sci., vol. 3, p. 32, as Asterias.)

Locality.—Cincinnati, O.

Remarks.—This species can hardly be said to have been described by Locke, but the illustration given by him, although imperfect in many details, is plainly a Paleaster. The brief description given above has been drawn up from the figure.

11.—P. SPECIOSA (Miller and Dyer) sp. 1878.

Pentagonal; rays obtuse at apex and about 2.50 inches from point to point across body; breadth of body about 1.33 inches; marginal plates small and somewhat hemispherical, enlarging and becoming square near the ends of rays; rectangular as they approach the disc, until at the body they are twice as long as wide; about fifty marginal plates between the apex of one ray and the next one, thus making about two hundred and fifty in all; dorsal surface with many plates, very prominent or somewhat conical in the center, each having three to eight indentations, thus giving them a star-like appearance; ambulacral grooves narrow and deep; two rows of ambulacral plates coming evenly together and forming a sharp ridge. (Jour. Cin. Soc. Nat. Hist., vol. 1, p. 30, as Palaeasterina. Palaeasterina approximata M. & D., Ibid. p. 31.)

Locality.—Richmond, Ind., Waynesville and Preble Co., O.

Remarks.—This species was originally described as a species of Palasterina. The presence of the marginal plates would seem to exclude it from that genus, and we have therefore placed it in Palaeaster. The species described as P. approximata presents so few points of difference that we regard it as a synonym. The dorsal surface of approximata is described as "coarsely granular." The space between the marginal and oral plates is stated to be filled by many smaller plates, and the madreporiform tubercle is "conical and striated longitudinally." The two latter features are not described under speciosa.

B. Ambulacral grooves narrow.

12.—P. SHAFFERI Hall, 1866.

Pentagonal; rays five, acute, seven-eighths inch long; ambulacral groove narrow, with two rows of ambulacral plates of about equal
length and breadth near middle of ray; marginal plates moderately convex, twenty-two or twenty-three in number, gradually decreasing in size toward the extremity of ray, each plate marked by a scar for the attachment of a spine; adambulacral plates somewhat smaller, about the same number, alternating with marginal ones; basal pair of plates (oral) about ten, elongated triangular, slightly constricted near middle; upper surface of rays with three rows of sub-nodose plates, the outer rows with a strong spine on each plate. (Rept. N. Y. State Mus. Nat. Hist, 1866, p. 284: 20th Rept. N. Y. State Mus. 1870, p. 326.)

Locality.—Cincinnati, O.

13.—P. simplex M. and D. 1878.

Body pentagonal; rays longer than diameter of body and tapering; body four lines in diameter, and rays probably two inches in length when perfect; marginal plates nine or more, the one at the junction of any two rays large and angular-ovate, the smaller end extending up between two marginal plates, while the larger one extends into an angle formed by two adambulacral plates; ambulacral groove very narrow; adambulacral plates about twenty-two, somewhat oblong, their breadth extending along the length and their length across the ray; oral plates ten, irregular or elliptical, with a triangular extension into the oral opening. (Jour. Cin. Soc. Nat. Hist., vol. 1, p. 29.)

Locality.—Raysville, O.

14.—P. longibrachiatus S. A. Miller, 1878.

Pentagonal; rays more than twice as long as diameter of body; breadth of body about six lines, length of rays about one and three-tenth inches; marginal plates spheroidal, gradually enlarging from tip to base of ray, about thirty-four, or a few more, in number, junction between rays formed by two pieces; ambulacral groove very narrow; ambulacral plates of the same form as, but larger than, marginal plates near ends of rays, but smaller than them near the body; no ambulacral plates within four plates of the two pieces at junction of rays. (Jour. Cin. Soc. Nat. Hist., vol. 1, p. 102.)

Locality.—Clarksville, Ohio.
15.—P. INCOMPTUS Meek, 1872.

Pentagonal, small; rays short, about 0.35 inch long and one and one-half times as long as broad, tapering rapidly to the apex and obtusely angular in form; body about equal to rays in diameter; dorsal surface of rays with three or perhaps four rows of plates, wider than long, about nine in each row, increasing rapidly in size toward the base: disc composed of smaller pieces; all the plates granulose but apparently spineless; madreporiform tubercle rather small, oval or circular, nearly flat and marked by fine irregularly interrupted striae. (Am. Jour. Sci, 3d ser. vol. 3, p. 275: Ohio Paleont., vol. 1, p. 64.)

Locality.—Cincinnati, O.

16.—P. CLARKANUS S. A. Miller, 1880.

Pentagonal; rays one-half the diameter of the body; rapidly tapering to a point and one-fifteenth of an inch long; body two-fifteenths inch in diameter; marginal plates probably six on each side of each ray, with three series of interlocking plates on the dorsal surface of each ray between the marginal plates; madreporiform tubercle and ventral surface unknown. (Single specimen.) (Jour. Cin. Soc. Nat. Hist. vol. 1, p. 102. as P. clarkei Ibid., vol. 3, 1880, p. 236 as P. clarkanus.)

Locality.—Cincinnati, O.

Remarks.—The original name proposed for this species was Clarkei. It was subsequently found that this name was preoccupied and so the name clarkanus was substituted.

17.—P. ANTIQUA (Troost) Sp., 1835.

Body of medium size; rays five, flexuose; marginal plates large, somewhat quadrangular, the outer faces subnodose; basal plates of the series single, broadly triangular, with slightly truncated lateral angles, the obtuse angle directed toward the axil of the ray; the small triangular space between the marginal and adambulacral plates filled by small granules or plates; adambulacral plates small, twice as numerous as the marginal ones; basal plates of the range elongated, triangular; ambulacral grooves with a single row of subquadrate ossicles alternating with the adambulacral plates; dorsal surface

**Locality.**—Big Harpeth River, Davidson Co., Tenn.

**Remarks.**—The description given by Troost is very imperfect. That given above is by Hall, who examined the type specimen and redescribed it, placing it provisionally in the sub-genus Argaster. This seems justified in the single row of ambulacral ossicles, the typical species of *Palaesler* having two rows.

Genus 2.—*PETRASTER* Billings, 1858.

“This genus has both marginal and adambulacral plates, with a few disc plates on the ventral side. The general form is deeply stellate and the rays long and uniformly tapering. A single specimen has been collected, and, as it shows the under side only, the character of the dorsal surface can not be given. The structure of the mouth is also unknown.” “It differs from *Palaslerina* by the presence of large marginal plates outside of the disc plates.” (Canadian Organic Remains, decade 3, p. 79.)

**Remarks.**—The figure of *Petraster rigidus*, the type, shows only two rows of plates on each side of the ambulacral groove at the ends of the rays, and three at the base. There are only about seven plates in the central row near the disc, with a single plate at the junction of any two arms at the disc. This plate is nearly square with the angles directed toward the disc and outward between the rays. The description is very unsatisfactory and it might possibly be well to consider it as a synonym of *Palaesler*. Prof. James Hall states* that the type specimens of the genus, examined by him, are plainly referable to *Palaesler*. He places the following species in that genus. It is here kept distinct provisionally.

1.—*P. wilberanus* Meek, 1861.

Diameter in its larger part one inch, and in its smaller 0.33 inch; rays slender with two ranges of plates on each side of the ambulacral groove on the ventral side; about the same size in each row, and sometimes alternating; all rather prominent, those in the outer range projecting in the form of small nodes; about twenty-three pieces on each

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side of the groove; groove very narrow; dorsal surface probably covered with small granules or bases of small spines, but this is not certainly known. (Proc. Acad. Nat. Sci. Phila., for 1861, p. 142.)

Locality.—Oswego, Ills.

Remarks.—This species is the only one so far referred to this genus from rocks of our group. In his description Meek considers it as related to *P. rigidus*, the type. The age of the rocks in which it was found is Trenton or Hudson River and it is inserted here in the hope that more information may be secured relating to it.

Genus 3.—PALASTERINA (McCoy) Salter, 1857.

Pentagonal, depressed, the arms a little produced, with three or five principal rows of tubercles above, combined with a plated disc which fills up the angles; ambulacra rather shallow, of sub-quadrate or slightly transverse ossicles, bordered by a single row of squarish, large plates, the lowest of which (*adoral adambulacral plates, Huxley*) are large and triangular, having combs of spines. (Brit. Pal. Foss., p. 59 (proposed but not described); Salter. Ann. and Mag. Nat. Hist., ser. 2, vol. 20, Nov. 1857, p. 324. Billings, Canad. Org. Remains, decade 3, 1858, p. 76 )

Remarks.—Two species have been referred to this genus from our region, but as already noted they are said to have marginal plates, which are absent from the present genus. They have therefore been referred to *Palaeaster* and will be found under *P. speciosa*. (M. and D.) sp.

Genus 4.—STENASTER Billings, 1858.

No disc; rays linear, lanceolate or petaloid; grooves bordered by solid oblong or square adambulacral plates; oral plates triangular, ten; two rows of ambulacral pores; dorsal side of disc and rays covered with small plates which appear to be tubercular and not closely fitted together. (Canadian Org. Remains, Decade 3, p. 77.) *Urasterella* McCoy, 1851. Proposed but not described )

Remarks.—It has been proposed by Prof. Hall* to adopt the name *Urasterella* for *Stenaster*. The argument advanced is that the two genera are equivalent and McCoy’s name has precedence. As far as date of proposal is concerned this is so, McCoy’s name dating

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* 20th Rept. l. c. p. 289.
from 1851 and Billing's from 1858. But McCoy did not describe his genus, simply referring two species to it. Hall considers that *Urasterella* and *Palasterina* stand on the same footing as they were proposed at the same time and in the same place. But *Palasterina* was regularly described by Salter in 1857. *Urasterella* has never, so far as known, been described at all. We have, therefore, retained the name given by Billings.

1.—*S. grandis* Meek, 1872.

Attaining a very large size with the body or disc comparatively small or only the breadth of the united inner ends of the five rays; rays long, slender, gradually tapering and very flexible, widest at their immediate connection with the body where they seem to be more or less depressed, but becoming more nearly terete further out; dorsal surface of disc and arms composed of numerous subtrigonal pieces that rise into pointed tubercles or sometimes assume almost the character of short spinules, and arranged in quinquefoil order, so as to form about eight rows near the middle of the rays; those of the two outer rows slightly larger than the others; dorsal pores apparently rather large, and passing through between the concave sides of contiguous pieces; ventral surface of disc unknown; ventral surface of rays with a single row of transverse, adambulacral pieces on each side of a well defined, rather deep and moderately wide ambulacral groove; adambulacral plates rather more than twice as long as wide, with their longer diameters at right angles to the ambulacral groove, and rounding over from end to end so as to be more prominent in the middle, connecting with each other by small projecting processes and corresponding sinuses on the opposite side; breadth of disc 0.63 inch; length of rays 2.40 inches; breadth at junction with body 0.36 inch; diameter from tip to tip of rays 5.50 inches. (Am. Jour. Science, ser. 3, vol. 3, p. 258; Pal. of Ohio, vol. 1, p. 66.)

*Locality.*—Richmond, Ind.

*Remarks.*—Prof. Meek in his remarks in Paleontology of Ohio quotes with approval Hall's suggestion as to the use of *Urasterella* for *Stenaster*, but as already noted we have preferred to retain the latter name.

2.—*S. harrisi* (S. A. Miller) sp. 1879.

Body pentagonal; rays twice as long as diameter of central part of body, flexuous, uniformly tapering to an acute point; marginal
plates wanting; ambulacral furrow narrow; ambulacral plates in two rows; adambulacral plates small, flattened, sub-circular, twenty-five or thirty in number, gradually decreasing in size from apex to base of rays; oral plates ten, each somewhat triangular; dorsal surface of rays with three (?) rows of plates, extending over the adambulacral row on ventral surface. (Jour. Cin. Soc. Nat. Hist., vol. 2, p. 117, as Paleaster harrisi.

**Locality.**—Waynesville, O.

**Remarks.**—Although originally described as a species of Paleaster the distinct assertion that the marginal plates are wanting seems to take it out of that genus, where the marginal plates is a chief characteristic. We have therefore, ventured to put it into Stenaster.

**Class 2.**—OPHIUROIDEA.

To this class belong the "brittle-stars," or those forms of star-fish that lose their arms readily on being disturbed. It may be defined as follows:

Body stellate, consisting of a central disc containing the viscera, and of elongated, often flexible arms, which are sharply defined from the disk, do not contain prolongations of the alimentory canal, and are without open, ambulacral grooves on the under surface.*

**Genus 1.**—PROTASTER Forbes, 1849.

"Body circular, covered with squamiform plates; genital openings in the angles of junction of the arms beneath; arms (simple) formed of alternating ossicula. (Mem. Geol. Sur. Gt. Britain; decade 1, pl. 4.)

**Remarks.**—The above is the original description given by Forbes. Salter in 1877 (Ann. and Mag. Nat. Hist., 2d ser. vol. 20, p. 325), re-defined it as follows: "Arms elongated, extending much beyond the circular, closely reticulate disc; the arms are composed of two rows of deeply sculptured plates, spinous at the edge, and below of two rows of elongated ambulacral ossicles, bordered by a row of large spinous plates; the basal ossicles of the ambulacra, bordering plates and disc, combined to form a petaloid mouth below." Another feature still is the presence of bunches of lateral spines on the plates.

of the ventral surface. Two species have been referred to the genus from our region, as given below.

1.—P. (?) GRANULIFERUS Meek, 1872.

Disc small, apparently circular; rays rather slender and of unknown length; dorsal surface covered by an integument composed of innumerable minute grains of calcareous matter; ventral side of disc apparently provided in the interradial spaces with minute spines directed outward; arm pieces regularly alternating, and apparently rectangular at their inner ends and not interlocking along the minute mesial impressed line, wider than long, each excavated at the anterior outer end so as to form a large pore or pore-like depression and divided transversely by a furrow into two parts, the anterior end very short and the posterior longer, marked by a minute pit at its inner end; about eight or nine pieces in each range of each row, included within the margin of the disc; outer arm pieces (adambulacral) smaller than those of the inner ranges, and placed, edge upwards, with an oblique outward direction, so as to imbricate toward the extremities of the rays; each bearing one or more minute articulating spines; breadth of disc 0.43 inch; breadth of arms at their inner ends 0.10 inch. (Am. Jour, Sci., ser. 3, vol. 4, p. 274.)

Locality.—Moore’s Hill, Indiana.

2.—P. MIAMIENSIS S. A. Miller, 1882.

Disc four lines in diameter; rays one inch long, flexuous and tapering to a point; dorsal surface unknown; ventral surface between the rays with the plates so ankylosed that “no special definition of them can be given;” rays with two series of sub-quadrangular ambulacral ossicles alternating with each other at the bottom of the ambulacral plates with spines; oral plates five. (Jour. Cin. Soc. Nat. Hist., vol. 5, p. 116.)

Locality.—Waynesville, O.

Remarks.—This is a very unsatisfactorily defined species and needs fuller material.

Genus 2.—TAENIASTER Billings, 1858.

“Body deeply stellate; no disc or marginal plates; rays long, slender, flexible, and covered with small spines; two rows of large
ambulacral pores; adambulacral plates elongated, sloping outwards so that they partly overlap each other; adambulacral ossicles contracted in the middle, dilated at each end.” (Can. Organic Remains, decade 3, p. 80.)

1.—T. ELEGANS S. A. Miller, 1882.

Body deeply stellate; rays long, slender, flexible, margined on either side with a row of spines; probable diameter from tip to tip of rays one and one-quarter inches; dorsal surface of rays rounded with a single row of plates; ventral side marked by a furrow in the center, separating two series of plates or ossicles; plates slightly longer in the direction of the ray than across it, breaking joints alternately in the center where they are slightly contracted. (Jour. Cin. Soc. Nat. Hist., vol. 5, p. 41.)

Locality.—Waynesville, O.

Genus 3.—PROTASTERINA Ulrich, 1878.

Rays five, slender, flexible, and extending much beyond the circular and minutely granular disc, which is provided with short, slender, outwardly directed spines; inner ray pieces regularly alternating, of an hour glass shape, and interlocking along the median line; outer ray pieces elongated, directed obliquely outward, so as to partly overlap each other; two rows of large pores between the inner and outer ray pieces, which in some species appear to have been occupied by loosely-fitting, sub-pyramidal plates, some of which have a deep depression in the top, as though perforated; oral plates ten, each pair formed by two of the outer ray pieces. (Jour. Cin. Soc. Nat. Hist., vol. 1, p. 95.)

1.—P. FIMBRIATA Ulrich, 1878.

Disc of medium size, circular; dorsal surface covered with a granular integument; ventral surface with a large number of outwardly directed short and slender spines; oral plates ten, the inner edges with five spines, while extending from each pair over the mouth, is a bundle of rather long spines; rays apparently very flexible, contracted toward the mouth; six series of plates on the ventral surface of each ray, the two middle series alternating and interlocking along the mesial line, and twice as long as wide; each contracted in the middle on the inner side to admit the wide edges of the two immediately opposite, forming on the outer side a pore-like impression; four plates in each
range of each ray are included within the disc, the series ending abruptly about one and one-half lines from the oral plates; sixteen plates in each range on the rays; pores apparently closed by obtusely conical or pyramidal plates, some with a depression in the top; marginal plates flat placed on edge and directed outward so as to overlap each other, the edges toward the ventral surface and pointing toward the ends of the rays, lined with ten or twelve short, club-shaped spines; dorsal surface of rays with two rows of alternating and interlocking plates, deeply sculptured near the disc and about as long as wide, becoming gradually less excavated and longer in proportion to the width at the tips of the rays; on each side they articulate with the upper edge of the oblique marginal plates; disc 0.60 inch broad; rays 0.16 inch broad at disc, and 0.88 inch long from the oval plates.


Locality.—Covington, Ky.

Remarks.—In this lengthy description we have many of the generic characters repeated. The author says it is "related to Protaster flexuosus." M. and D.

2.—P. FLEXUOSA (M. and D.) sp. 1878.

Disc varying in diameter from one-quarter to one-half inch, composed of very thin, small plates; rays very flexuous, the dorsal surface with four series of plates on each side near the disc, the two inner forming an angular ridge, alternating, and presenting an appearance like two series of hour-glasses; outer or marginal plates spinous, the spines directed toward the apex of the ray; three series of pores on the rays; plates slightly longer than wide and about four to one line; rays cross the disc on the dorsal side and unite near the centre; ventral surface with two rows of spines springing from the marginal plates on each side of the rays. (Jour. Cin. Soc. Nat. Hist., vol. 1, p. 31 as Protaster.)

Locality.—Cincinnati, O.

Remarks.—This species seems to present an aggregate of characters which justifies in placing it in Protasterina. The principal one of these characters is the interlocking series of plates presenting the hour-glass appearance.

(To be continued.)