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(WITH ONE PLATE)

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The Edrioasteroidea, a group of Paleozoic echinoderms, regarded by specialists either as a distinct class of the Pelmatozoa allied to the cystids or as an aberrant order of the same division, has been the subject of so many detailed observations and changes in nomenclature that much confusion exists in its classification. Many of the genera have inexact limits assigned them, because they are based upon incorrect illustrations or described from species other than the cited genotype, or, again, because they are founded upon characters of uncertain value. Lastly, some authors, without regard to the rules of nomenclature, changed the generic endings to suit their ideas as to the relationships of the group, *Agelacrinites*, for example, becoming first *Agelacrinus* and later *Agelacystis*. Furthermore, it must be remembered that the camera-lucida drawings of years ago resulted in reversed images, the right side becoming the left, which in the edrioasteroids gave rise to a serious error since the direction of the ambulacra, a generic character now believed to be important, thus was reversed. However, most students paid little attention to the extent and direction of curvature of the ambulacra, including in the same genus forms most diverse in these respects.

In preparing the present classification the writer first of all proved, at least to himself, from a study of several hundred specimens of several Cincinnati species, that the amount of imbrication of the interambulacral plates, the width of the peripheral border of plates, and the number of arms or ambulacra may vary even in the same species; but the plate structure of the ambulacral and oral areas, and the direction and extent of curvature of the ambulacra, remained constant, thus affording good generic characters.

In their simplest form the edrioasteroids have a flexible theca or sacklike body composed of numerous more or less polygonal plates having a mouth on the upper surface at the central point of radiation of five straight or curved arms or ambulacra separated by interambulacral plates, and an anus with valvular covering occupying part

of an interray with a hydropore located between it and the mouth. These primitive echinoderms, free or attached by a part of the lower surface, developed into parasitic circular flattened forms, into elevated sacklike bodies or into cylindrical objects bearing the ambulacra at the top of a fused mass of plates. Starting at the left of the anal area and proceeding clockwise, the ambulacra are designated as follows: 1, left posterior; 2, left; 3, anterior (opposite the anal area); 4, right; 5, right posterior. These numbers are employed in the following descriptions.

Through the study of the Springer and Ulrich collections of Edriasteroidea in the National Museum, and of material lent by other institutions, the writer has been enabled to review the structure of most of the known genera and species of this group, the generic results of which are offered below. Here, the old genera are briefly redefined and six new generic names are proposed. This paper is introductory to a more complete publication that will include descriptions of additional new species upon which this classification is based.

Class EDRIOASTEROIDEA Billings, 1854-58

(Thyroidea Chapman, 1860; Agelacrinoidea S. A. Miller, 1877-1883; Cystasteroidea Steinman, 1888; Thecoidea Jaekel, 1895; Cystostellarioidea Steinman, 1904.)

Family AGELACRINITIDAE, new name

(Agelacrinidae Jaekel, 1899; Thecocystidae Jaekel, 1899)

Theca flexible, composed of thin plates attached temporarily or permanently by the greater part of the aboral surface and with ambulacra confined to the oral surface. A single row of ambulacral flooring plates overlapping proximally.

STROMATOCYSTITES Pompeckj, 1896

(*Stromatocystis* Bather, 1900)

Theca depressed, pentagonally globular in form with oral surface bearing five narrow, straight ambulacra separated by polygonal mosaic interambulacral plates with numerous intervening pores and the under surface completely occupied by smaller, less regular polygonal plates. Anal area slightly elevated, indistinct.

Genotype.—*S. pentangularis* Pompeckj, 1896. Middle Cambrian of Bohemia. *S. balticus* Jaekel, 1899, *S. walcotti* and var. *minor* Schuchert, 1919 are other species of the genus.

WALCOTTIDISCUS, n. gen.

Pentagonal form and general shape of theca as in *Stromatocystites*, but the oral face bears curved ambulacra, four (1-4) directed to the left and one (5) to the right. Furthermore, the edge of the oral surface is composed of a narrow band of very small nodose plates and the under side of larger polygonal plates imbricating. Anal area indistinct.

Genotype.—*W. typicalis*, new species. Middle Cambrian of British Columbia.

WALCOTTIDISCUS TYPICALIS, n. sp.

Plate I, fig. 1

Type specimen, free, depressed, globular, subpentagonal in outline, imbedded and somewhat distorted in hard shale. Oral face with five slightly curved ambulacra, four directed to the left and one, the right posterior, to the right, separated by polygonal interambulacral plates very slightly overlapping. Edge of oral side formed by a band consisting of five or more rows of very small elongate imbricating plates; basal side of theca as shown where pushed over oral face, occupied by large elongate polygonal, imbricated plates. Anal area not distinguishable with certainty.

Occurrence.—Burgess shale of Middle Cambrian, Burgess Pass near Field, B. C. (loc. 35 k).

Holotype.—U.S.N.M. no. 90754.

CYSTASTER Hall, 1871

(*Thecocystis* Jaekel, 1899)

Theca an elongate sack with the lower end attached to some foreign object. Ambulacra short and straight, five in number, with plates often rather nodose. Interambulacrals rounded or polygonal, mosaic, very minute (0.25 mm in diameter). Anal pyramid of 10 elongated, abruptly raised plates.

Genotype.—*Hemicystites* (*Cystaster*) *granulatus* Hall, 1871. Ordovician (Maysville) of Ohio.

CINCINNATIDISCUS, n. gen.

(*Hemicystites* of authors not Hall)

Like *Cystaster* except that the theca is not sacklike but depressed, attached, and that the interambulacral plates are squamose and imbricate distinctly, divided into larger central plates and a marginal zone of small nodose ones. Anal pyramid of nodose plates.

Genotype.—*Agelacrinus* (*Hemicystites*) *stellatus* Hall, 1866. Ordovician (Maysville) of Ohio. *Hemicystites carnensis* Foerste, 1914, belongs to this genus.

CARNEYELLA Foerste, 1916

Theca typically elevated, sacklike, attached by narrow basal part but also may occur as a thin circular expansion. Ambulacra curved, four (1-4) to left and one (5) to the right, with two rows of covering plates elevated and alternating with each other along the middle line. Oral area composed of three plates, one large and two small. Anal area of many small plates radially arranged. Surface of plates ornamented with minute pits and nodes.

Genotype.—*Agelacrinus* (*Lepidodiscus*) *pileus* Hall, 1866. Ordovician (Maysville) of Ohio. *Carneyella vetusta* Foerste, 1914, is related to *C. cincinnatiensis*, n. sp., next described. *Carneyella valcourensis* Clark, 1920, is doubtfully referred here.

CARNEYELLA CINCINNATIENSIS, n. sp.

Plate 1, fig. 10

Agelacrinus (*Lepidodiscus*) *cincinnatiensis* Hall (not Roemer), Descr. new species fossils Cincinnati, Ohio, p. 214, pl. 2, fig. 7, 1871 (advance sheets, p. 6, 1866); 24th Rep. New York State Cab. Nat. Hist., p. 214, pl. 6, fig. 7, 1872.

This well-marked species, erroneously referred to *Agelacrinus* (now *Isorophus*) *cincinnatiensis* Roemer, is readily distinguished from that form by its thin, depressed, almost flat theca attached by its entire aboral portion. Furthermore, the ambulacral plates are less elevated, all the plates are rather papillose, and there are only three oral plates.

Occurrence.—Maysville division (Corryville beds) of the Ordovician, Warren County, Ohio.

Holotype.—U.S.N.M. no. 40743.

ISOROPHUS Foerste, 1916

Theca depressed, circular, attached by the entire under surface. Ambulacra composed of two rows of plates with an intercalated series often present, more or less curved, four (1-4) to the left and the right posterior (5) to the right. Oral area occupied by numerous small plates. Margin composed of numerous rows of small plates slightly increasing in size inward. Interambulacral plates polygonal, becoming slightly imbricated. Anal area a circle of triangular plates regularly arranged.

Genotype.—*Agelacrinus cincinnaticensis* Roemer, 1851. Ordovician (Maysville) of Ohio, etc. Other species of *Isorophus* are *Agelacrinus austini* Foerste, 1914, *A. faberi* Miller, 1894, *A. warrenensis* James, 1883, and *A. holbrooki* James, 1878.

ISOROPHUSELLA, n. gen.

Like *Isorophus* but ambulacra 1, 2, and 3 directed to the left and 4 and 5 to the right, and the interambulacral plates strongly imbricating.

Genotype.—*Lebetodiscus inconditus* Raymond, 1915. Ordovician (Trenton) of Ontario, Canada.

ISOROPHUSELLA INCONDITUS (Raymond)

Plate I, fig. 11

Lebetodiscus inconditus Raymond, Ottawa Nat., vol. 29, pl. 1, fig. 1, 1915.

Theca a thin, slightly convex, circular disk, attached to or resting upon a limestone bed by its entire aboral surface, about 20 mm in diameter, exhibiting on its oral face a broad peripheral band of minute, closely imbricating plates, five ambulacral areas of which the oral portion is composed of many small irregular, angular plates, and each ambulacrum has two rows of covering plates alternating with each other and frequently developing additional small accessory plates along the midline between them. Ambulacra short, rather broad, three (1-3) curving to the left and two (4, 5) to the right. Interambulacral areas of larger, narrow, strongly imbricating plates. Anal area rather distinct, consisting of 10 elongate triangular smooth plates in one circle meeting at the center but not rising above the general surface.

Although very similar to species of *Isorophus*, this interesting form is readily distinguished by the different arrangement of the ambulacra.

Occurrence.—Trenton limestone, Hull, Quebec.

Plesiotype.—U.S.N.M. no. S.3871, Springer Coll.

STREPTASTER Hall, 1872

Theca as in *Carneyella*, except that the ambulacra all revolve strongly toward the left and are composed of highly elevated plates. Interambulacrals are small, polygonal, mosaic plates, 0.5 to 1.0 mm in diameter.

Genotype.—*Agelacrinus vorticellatus* Hall, 1866. Ordovician (Maysville) of Ohio. *S. reversatus* Foerste, 1914, and *S. septem-brachiatus* Miller and Dyer, 1878, are other species of *Streptaster*.

LEBETODISCUS Bather, 1908

Theca depressed, circular. Ambulacra curved, five in number, all directed toward the left, with mosaic interambulacral plates. Ambulacral plate structure apparently as in *Carneyella*. Anal area well defined in slightly wider interradius.

Genotype.—*Agelacrinites dicksoni* Billings, 1857. Ordovician (Trenton) of Ontario, Canada. *L. loriformis* Raymond, 1915, is a second described species.

FOERSTEDISCUS, n. gen.

Like *Lebetodiscus*, but ambulacra all directed to the right, short, broad, and strongly curved, and interambulacral plates polygonal but overlapping toward the center and highly imbricating around the periphery. Anal area of many small, irregularly arranged plates in slightly wider interradial area.

Genotype.—*F. grandis*, new species. Ordovician (Trenton) of Kentucky.

FOERSTEDISCUS GRANDIS, n. sp.

Plate 1, fig. 12

Theca a flattened disk, 25 mm in diameter, resting upon or attached to a layer of limestone. Ambulacra five, short, broad, all curved to the right, consisting of two rows of elongate covering plates slightly raised along the midline, and a single row of floor plates. Interambulacrals large, imbricating, but flat in the central areas, narrow, more numerous, and piled up on edge along the margin. Anal area large, distinct, occupying a slightly wider space, composed of many small imbricating plates arranged in circles, the smallest in the center.

Although resembling *Lebetodiscus dicksoni* (Billings), the right-handed arrangement of the ambulacra in this present species is a ready means of separation.

Occurrence.—Curdsville division of the Trenton, near Troy, Woodford County, Kentucky.

Holotype.—U.S.N.M. no. S.3191, Springer Coll.

PYRGOCYSTIS Bather, 1915

Oral surface of five broad, straight ambulacra mounted on a high cylindrical turret composed of wide, thin, closely imbricated plates.

Genotype.—*P. sardesoni* Bather, 1915. Ordovician (Decorah) of Minnesota. *Scalpellum sulcatum*, *procerum*, and *cylindricum* Aurivil-

lius, 1892, *Pyrgocystis octogona* Richter, 1930, *P. grayae* Bather, 1915, *P. ansticei* Bather, 1915, and *P. batheri* Ruedemann, 1925, are the other species of this genus.

HEMICYSTITES Hall, 1852

(*Hemicystis* Haeckel, 1896)

Theca a thin, flattened disk with oral arrangement and pitted plate structure of *Carneyella*, but ambulacra are short, broad, and straight. Anal pyramid elevated and composed of a circle of triangular plates regularly arranged.

Genotype.—*H. parasitica* Hall, 1852. Silurian (Rochester) of New York. *Agelacrinites bellulus*, *bohemicus*, *confertus*, *latiusculus*, *simplex*, *tener*, and *velatus* of Barrande, 1887, *A. rectiradiatus* Shideler, 1918, and *Agelacrinites billingsi* Chapman, 1860, *Lebetodiscus youngi* Raymond, 1915, and *L. chapmani* Raymond, 1915, are described species of *Hemicystites*.

THRESHERODISCUS Foerste, 1914

Agelacrinitidae with branched ambulacral rays having a pronounced trimerous origin. Interambulacrals large, squamose, imbricating in central part and smaller along border.

Genotype.—*T. ramosus* Foerste, 1914. Ordovician (Trenton) of Ontario, Canada.

AGELACRINITES Vanuxem, 1842

(*Agelacrinites* authors; *Agelacystis* Haeckel, 1895; *Haplocystites* Roemer, 1852; *Haplocystis* Bather, 1899)

Thin parasitic disks attached by entire aboral surface. Ambulacra five, long, narrow, much curved; two (4, 5) to the right and three (1-3) to the left. Interambulacral plates mosaic and sculptured, although slightly imbricating. Periphery formed by several rows of small plates followed by one row of much larger elongate ones. Anal area a circle of triangular, regularly arranged plates.

Genotype.—*A. hamiltonensis* Vanuxem, 1842. Devonian (Hamilton) of New York. *A. ephraemovianus* Bogolubov, 1926, *A. hanoveri* Thomas, 1924, and *A. rhenanus* Roemer, 1851, from the Devonian, and *A. blairi* Miller, 1894, *A. legrandensis* Miller and Gurley, 1894, from the Mississippian are referred to this genus.

DISCOCYSTIS Gregory, 1897

(*Echinodiscus* Worthen and Miller, 1883 (not Agassiz);
Ageladiscus Miller, 1897)

Like *Agelacrinites* except that four ambulacra are curved to left and one, the right posterior (5), to right, and that body is well developed and sacklike with many rows of elongate, narrow marginal plates.

Genotype.—*Echinodiscus optatus* Worthen and Miller, 1883 = *D.* (*Agelacrinites*) *kaskaskiensis* Hall, 1858. Mississippian of Illinois. *Echinodiscus sampsoni* Miller, 1891, is another species of this genus.

COOPERIDISCUS, n. gen.

Body depressed globular, free, entirely covered with plates; ambulacra long, very narrow, much curved, all turning to the right. Interambulacral plates strongly imbricate. Anal pyramid of regular triangular plates meeting at a point.

Genotype.—*Lepidodiscus alleganius* Clarke, 1901. Devonian (Chemung) of New York.

LEPIDODISCUS Meek and Worthen, 1868

Like *Cooperidiscus* but ambulacra 1-4 curve strongly to the left and 5, the right posterior one, to the right. Interambulacral plates small, strongly imbricating. Anal pyramid well developed.

Genotype.—*Agelacrinites squamosus* Meek and Worthen, 1868. Mississippian. *Agelacrinites beccheri* Clarke, 1901, *A. buttsi* Clarke, 1901, *Lepidodiscus lebouri* Sladen, 1879, and *L. milleri* Sharman and Newton, 1892, are the known species of this genus.

ULRICHIDISCUS, n. gen.

Body semiglobose with the oral side occupied by five narrow but well-defined, very long ambulacra all strongly curving to the left, with a well-defined anal pyramid of many long triangular plates in one circle, and interambulacral areas composed of polygonal but slightly imbricating plates.

Genotype.—*Agelacrinites pulaskiensis* Miller and Gurley, 1894. Mississippian (Chester) of Kentucky.

Family EDRIOASTERIDAE Bather

Theca flexible, depressed, usually globular, attached by the small central excavated part of the aboral surface; ambulacra strongly

curved and passing on to aboral surface; floor plates arranged in two series, one on each side of the ray, and alternating along the median line.

EDRIOASTER Billings, 1858

(*Cyclaster* Billings, 1857, not Cotteau, 1856; *Agelacrinites* Forbes, 1848, not Vanuxem; *Edriocystis* Haeckel, 1896; *Aesiocystites* Miller and Gurley, 1894; *Aesiocystis* Bather, 1900)

Sacklike, flexible theca attached by a small central portion of the aboral surface and with the ambulacra passing from the oral to aboral sides. Interambulacral plates mosaic. Ambulacra strongly curved, four (1-4) to the left and one (5) to the right, with an anal pyramid composed of many small plates, irregularly arranged.

Genotype.—*Cyclaster bigsbyi* Billings, 1857. Ordovician (Trenton) of Canada. *Agelacrinites buchianus* Forbes, 1848, *Edrioaster levis* Bather, 1914, *E. saratogensis* Ruedemann, 1912, and *Aesiocystites priscus* Miller and Gurley, 1894, are other species of this genus.

DINOCYSTITIS Bather, 1898

Oral surface convex, with five narrow ambulacra all strongly curved to the left and aboral surface composed of a thin flexible integument of narrow imbricating plates with a small central orifice for attachment.

Genotype.—*D. barroisi* Bather, 1898. Devonian of Belgium.

Family CYATHOCYSTITIDAE Bather

Edrioasteroidea in which the aboral portion consists of a fused solid mass of plates attached permanently to some foreign object.

CYATHOCYSTITIS Schmidt, 1880

Theca with oral surface much as in *Stromatocystites* but mounted upon a solid fused mass of stereom and permanently attached at the aboral end.

Genotype.—*C. plautini* Schmidt, 1880. Ordovician (Echinospherites limestone) of Estonia.

CYATHOTHECA Jaekel, 1927

Like *Cyathocystis*, except that the ambulacral areas are apparently very narrow, practically hidden at the surface.

Genotype.—*C. suecica* Jaekel, 1927. Ordovician of Sweden.

POSITION UNCERTAIN

Family ASTROCYSTITIDAE, new name

(Steganoblastidae Bather)

ASTROCYSTITES Whiteaves, 1897*(Steganoblastus* Whiteaves, 1897)

Regarded by Bather as an edrioasteroid and by Hudson as a blastoid.

Family CYCLOCYSTOIDIDAE S. A. Miller, 1889

(order uncertain)

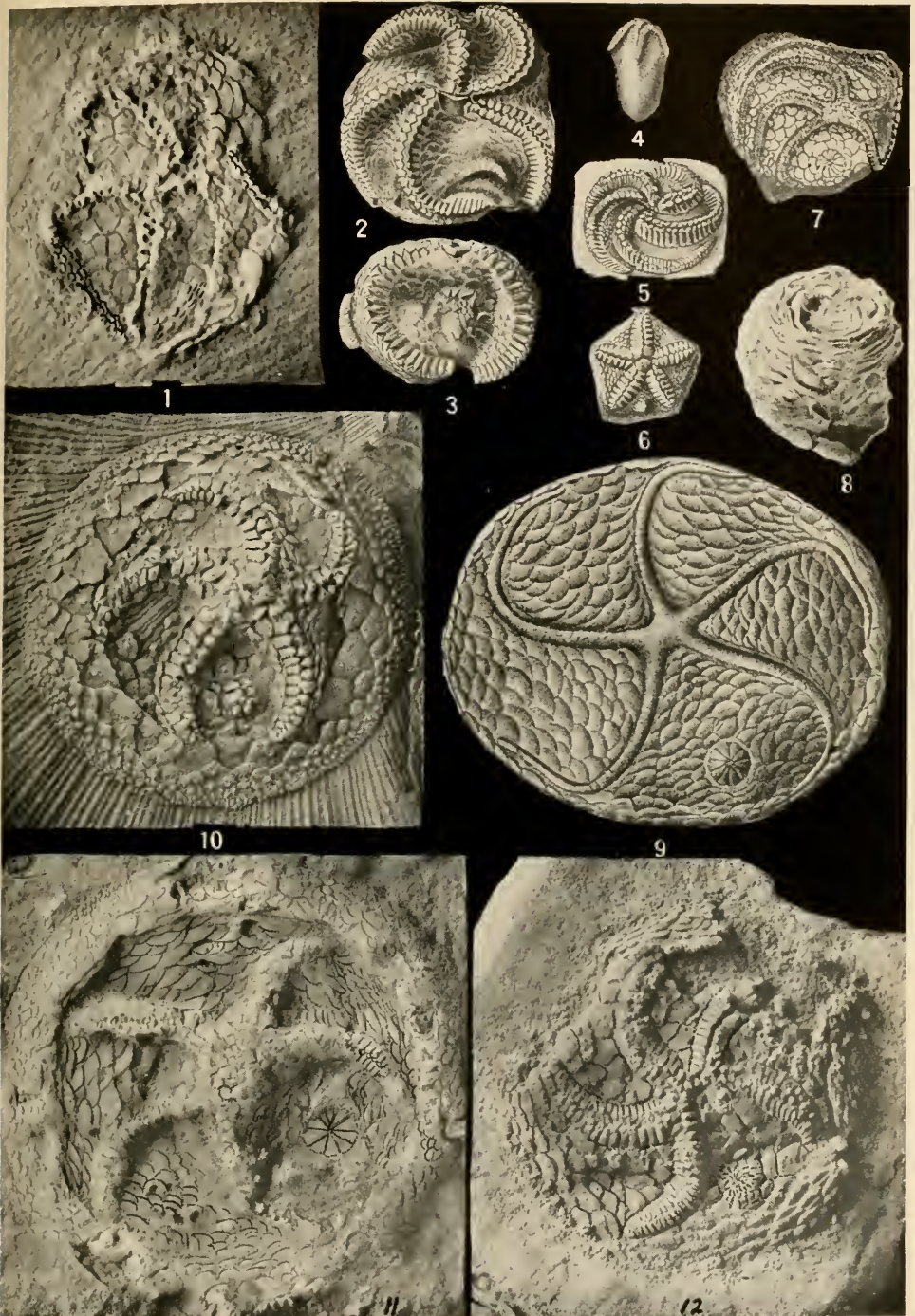
Genera *Cyclocystoides* Billings and Salter, 1858; *Narragwayella* Foerste, 1920; *Savagella* Foerste, 1920.

EXPLANATION OF PLATE

- FIG. 1. *Walcottidiscus typicalis*, new genus and species. The holotype, $\times 3$, a crushed theca showing the oral side. Middle Cambrian (Burgess shale) Burgess Pass, near Field, British Columbia.
- FIGS. 2, 3. *Carneyella (Agelacrinus) pileus* Hall, 1866. View of oral side of theca and lateral view, $\times 2$, showing the sacklike form. Maysville (Fairmount formation): Cincinnati, Ohio.
- FIG. 4. *Cystaster (Hemicystites) granulatus* Hall, 1871. Side view, $\times 2$, of the elongate theca. Maysville (Fairmount formation): Cincinnati, Ohio.
- FIG. 5. *Streptaster (Agelacrinus) vorticellatus* Hall, 1856. Oral side of theca slightly enlarged, exhibiting the elevated ambulacra all revolving toward the left. Maysville (Fairmount formation): Cincinnati, Ohio.
- FIG. 6. *Cincinnatiidiscus (Agelacrinus) stellatus* Hall, 1866. Oral side of the depressed, attached theca, with straight arms, $\times 2$. Maysville (Fairmount formation): Cincinnati, Ohio.
- FIG. 7. *Ulrichidiscus (Agelacrinus) pulaskiensis* Miller and Gurley, 1894. View of the semiglobose theca, natural size, showing strong curvature of all ambulacra to the left. Chester (Glen Dean formation): Pulaski County, Ky.
- FIG. 8. *Pyrogocystis sardsoni* Bather, 1915. Side view of theca, $\times 1\frac{1}{2}$, showing the solid basal portion of many imbricating plates surmounted by the oral surface. Black River (Decorah) shales: St. Paul, Minn.
- FIG. 9. *Cooperidiscus (Lepidodiscus) alleganius* Clark, 1901. Oral side of the free, globular theca, $\times 1\frac{1}{2}$, exhibiting the very narrow ambulacra all curved to the right and the highly imbricated interambulacral plates. Chemung formation: New York.
- FIG. 10. *Carneyella cincinnatiensis*, new species. View of the attached, thin circular theca with ambulacral structure of *Carneyella*, $\times 4$. Maysville (Corryville formation): Warren County, Ohio.

FIG. 11. *Isorophusella inconditus* (Raymond, 1915). Example, $\times 4$, a depressed circular expansion with the plate structure of *Isorophus* but with 3 of the ambulacra directed to the left and 2 to the right. Trenton limestone: Hull, Quebec, Canada.

FIG. 12. *Foerstediscus grandis*, new genus and species. The holotype, $\times 2$, a flat circular expansion with the ambulacra all directed toward the right. Trenton (Curdsville limestone): Near Troy, Woodford County, Ky.



EDRIOASTEROIDEA

(For explanation, see page 10.)