BULLETIN NO. 7

OF THE

ILLINOIS STATE MUSEUM

OF

NATURAL HISTORY

NEW AND INTERESTING SPECIES OF PALÆOZOIC FOSSILS.

By S. A. MILLER and Wm. F. E GURLEY.

Springfield, Illinois,
December 5, 1895.

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NEW AND INTERESTING SPECIES OF PALÆOZOIC FOSSILS.

BY S. A. MILLER AND WM. F. E. GURLEY.

SUBKINGDOM ECHINODERMATA.

CLASS CRINOIDEA.

ORDER PALÆOCRINOIDEA.

FAMILY ACTINOCRINIDÆ.

BATOCRINUS POLYDACTYLUS, n. sp.

Plate I, Fig. 1, view of calyx, arms and part of the column, azygous area on the right.

Species above medium size. Clayx short, saucer-shaped, about four times as wide as high; interradial areas slightly flattened; surface granular. Column medium size and composed of alternately larger and smaller plates.

Basals form an hexagonal disc, less than twice the diameter of the column, bearing a low rim around the depression for the attachment of the column. First primary radials more than twice as wide as high. Second primary radials quadrangular, nearly three times as wide as high. Third primary radials not much larger than the second, twice as wide as high, pentagonal, axillary, and support upon the upper sloping sides the secondary radials. In each lateral ray and in the ray opposite the azygous area there are two secondary radials, the last of which are axillary and bear three tertiary radials, the last one being axillary and bearing two arms; which gives to each of these rays eight arms. The ray on the right of the azygous area bears three secondary radials, the last one being axillary and bearing two arms, which gives to this ray four arms. The ray on the left of the azygous area bears, on the

distal side, three secondary radials, the last of which is axillary, and on the proximal side two secondary radials, the last of which is axillary, and bears on the distal side two tertiary radials, and on the proximal side three tertiary radials, the last one being axillary, giving to this ray five arms. There are, therefore, thirty-three arms in this species. The arms are composed of a double series of interlocking plates that are deeper than wide in the lower part, but commence to spread, at the upper third, and become perfectly flat, in the upper part, as they do in *Erelmocrinus*, but without the usual increase in width. The plates of the arms do not seem to lengthen, but instead of closing, so as to have an ambulacral furrow on the inner side, they become perfectly flat on both sides, or concave externally. Pinnules dense.

There are three regular interradials in each area, one large, the other two small, but of unequal length. There are seven azygous interradials, the first one heptagonal, in line with the first primary radials, and of about the same size. It is followed by three plates, in the second range, the middle one being the longer and larger one. On each side of the upper part of the middle plate there is a small plate that separates it from the radial series. Above the middle plate of the second range, there is an elongated plate that extends an angle to the top of the calyx. The vault is not exposed, but it bears a long slender proboscis, the end of which is broken off at the top of the specimen illustrated.

This specie will be distinguished by its depressed calyx, and thirty-three arms or seventeen ambulacral orifices, in the vault, and by the flattening of the arms in the superior part. This latter character, in a greater degree, possibly, has been regarded as a generic character in *Erelmocrinus*. This species and others hereinafter described show that the flattening of the arms is not of generic importance. Many species of *Batocrinus* show the tendency of the arms to expand or flatten toward the superior ends.

Found in the Keokuk Group, at Boonville, Missouri, and now in the collection of S. A. Miller.

BATOCRINUS SAMPSONI, n. sp.

Plate I, Fig. 2, azygous view of a specimen compressed so as to show calyx and arms; Fig. 3, lateral view of another specimen having part of the arms removed, showing vault, proboscis and the incurving part of the arms, some of which are broken off.

Species medium size. Calyx obconoidal, twice as wide as high; each radial series where unworn bears a slight angular ridge from the basal plates to the free arms; interradial areas flattened but very little; surface granular; truncated for a small column.

Basals form an hexagonal disc, one-half wider than the diameter of the column, and having a height less than the distance from the column to the margin. First primary radials wider than high, upper face slightly arcuate for the reception of the second radials. Second primary radials quadrangular, about twice as wide as high. Third primary radials pentagonal, a little larger than the second, not quite twice as wide as high, axillary, and support upon the upper sloping sides the secondary radials The distal side of each third primary radial, adjoining the azygous area, bears four secondary radials, the last of which is axillary, and supports upon each upper sloping side a free arm; the proximal side of each bears two secondary radials, the last of which is axillary and supports upon the distal side two tertiary radials, the last one being axillary and supporting upon each upper sloping side a free arm; the proximal side of each secondary radial bears three tertiary radials that support a single arm. This arrrngement gives to each of these rays five arms. In each lateral ray there are two secondary radials, the last one being axillary and supporting the tertiary radials. In one of these each distal series supports four tertiary radials, the last one being axillary and supporting upon each upper sloping side a free arm, and each proximal series supports three tertiary radials, the last of which supports a free arm which gives to this lateral ray six arms. In the other lateral ray, one of the distal series supports three tertiary radials, the last one being axillary and supporting upon each upper sloping side a free arm; the other distal series and each proximal series, support three tertiary radials each of which

supports a free arm, which gives to this lateral ray five arms. In the ray opposite the azygous area there are four secondary radials, the last of which is axillary and supports upon each upper sloping side a free arm, which gives to this ray four arms. There are, therefore, twenty-five arms, in this species. The arms are composed of a double series of interlocking plates that are deeper than wide, in the lower part, but flatten out above as they do in *Eretmocrinus*, but without the usual increase in width. Pinnules long and dense.

There are three regular interradials in each area, one large, the other two smaller and somewhat elongated. There are six azygous interradials, the first one heptagonal, in line with the first primary radials, and the largest plate in the calyx. It is followed by three plates, the central one being smaller than the lateral ones; and these by two elongated plates that connect with the plates of the vault. The vault is conoidal and larger than the calyx, and bears a long subcentral proboscis. The plates of the vault and proboscis are large and smooth.

This species will be distinguished by its general form, and twenty-five arms that are flattened toward their terminal ends. This latter character belongs to all species that have been referred to *Eretmocrinus*. This species and others herein described show that the flattening of the arms is not of generic importance, though, in a marked degree, it is no doubt of specific value. We have, heretofore, shown that the other characters ascribed to *Eretmocrinus* are possessed by different species of *Batocrinus* and that one and all are not of generic value.

Found in the Keokuk Group, at Boonville, Missouri, and now in the collection of S. A. Miller. The specific name is in honor of F. A. Sampson, the well known naturalist of Sedalia, Missouri.

BATOCRINUS VETERATOR n. sp.

Plate I. Fig. 4, view of calyx and arms opposite the azygous side, a little depressed, and arms broken off at the upper end.

Species medium size. Calyx obconoidal, two and a half times as wide as high; no radial ridges; plates slightly convex; sutures distinct, somewhat beveled; surface granular; column small.

Basals form an hexagonal disc twice as wide as the diameter of the column and having a height less than half the distance from the column to the margin. First primary radials one-half wider than high, and superior face nearly straight. Second primary radials quadrangular, about three times as wide as long. Third primary radials pentagonal, a little larger than the second, about three times as wide as long, axillary, and support on the upper sloping sides the secondary radials. In the ray opposite the azygous area there are three secondary radials on one side and an axillary plate that bears two arms; on the other, there are two secondary radials, the last of which is axillary and bears, upon one side, a tertiary plate, which supports a single arm, and upon the other a tertiary plate, which is followed by an axillary plate that bears two arms. There are, therefore, five arms in this ray. One of the lateral rays is constructed in the same manner and bears five arms. In the other lateral ray there are two secondary radials in each series, the last of which are axillary and bear, upon one side, two tertiary radials that support a single arm on each, and upon the other side two tertiary raidials, the last being axillary and supporting two arms. There are, therefore, six arms in this ray. The ray on the right of the azygous area also supports six arms, while the ray on the left of the azygous area supports seven arms, the proximal one being a single arm and the other three double arms. By this arrangement there are twenty-nine arms in this species. The arms are long and very slightly flattened toward the superior ends. Pinnules very dense.

In the regular interradial areas there are only two plates, one following the other. In the azygous interradial area the first plate is heptagonal, in line with the first primary radials and of about the same size. It is followed by three plates in the second range, which nearly fill the area, above these the sutures are indistinct in each of our specimens, but, apparently, there is only one plate, making five plates in this area. The vault is not disclosed in our specimens, but two of them show the broken ends of the proboscis, which is quite small.

The arms, in the specimen illustrated, are broken off and eroded toward the top, which causes the arms to appear to flatten more than they really do. Another specimen showing nearly the entire length of the arms, shows only a little flattening at the tips— about the same shown in *B. venustulus*.

This species is distinguished by its general form, number of interradials, and the peculiarity in the arrangement of its twenty-nine arms.

Found in the Keokuk Group, at Boonville, Missouri, and now in the collection of S. A. Miller.

BATOCRINUS VETUSTUS, n. sp.

Plate I, Fig. 5, azygous side view of the calyx and part of the arms; Fig. 6, opposite view of the same specimen.

Species medium size. Calyx obpyramidal, twice as wide as high; each radial series bears an angular ridge from the basal plates to the free arms; interradial areas flattened; sutures slightly beveled; surface granular; truncated for a small column.

Basals form an hexagonal disc one half wider than the diameter of the column and having a height less than half the diameter of the column. First primary radials wider than high, upper face slightly arcuate for the reception of the second radials. Second primary radials quadrangular, about twice as wide as high. Third primary radials pentagonal, except in the typical specimen, the one on the right of the azygous area is hexagonal, and the one opposite the azygous area is heptagonal, as shown in figure 5 Moreover, in the typical example, there are four primary radials, in one of the lateral series, as shown on the left of figure 6. The extra plate is pentagonal and inserted between the second and third primary radials. The third primary radials are of unequal size, axillary, and bear upon each upper sloping side secondary radials. On the right side of the azygous area, on the distal side, there are three secondary radials and an axillary plate that bears two arms, and on the proximal side two secondary radials, the last being axillary and bearing upon each upper side two

tertiary radials, each of which bears a single arm, which gives to this ray four arms. On the left side of the azygous area, on the distal side, there are four secondary radials that bear a single arm, and on the proximal side two secondary radials, the last of which is axillary, and bears upon the distal side two tertiary radials that bear a single arm, and on the proximal side three tertiary radials, the last being axillary and supporting two arms, which gives to this ray four arms. It will be noticed that the number of arms in each of these rays is the same, but the arrangement is reversed. In one lateral ray there are upon each side of the third primary radial four secondary radials, the last being axillary and supporting two arms, which gives to this ray four arms. In the other lateral ray there are upon each side of the third primary radial two secondary radials, the last being axillary and bearing upon each upper sloping side three tertiary radials, the last of which is axillary in three rays and supports two arms, and the other one supports a single arm, which gives to this ray seven arms. In the ray opposite the azygous area there are upon one side five secondary radials that bear a single arm, and upon the other side five secondary radials, the last being axillary and supporting two arms, which gives to this ray three arms. There are, therefore, twenty-two arms in this species. The arms are composed of a double series of interlocking plates that are deeper than wide, and, as far as preserved in the typical specimens, show no tendency to flatten toward the superior ends. Pinnules long and dense.

In part of the regular interradial areas there are five plates, one followed by two, and then one in the third, and one in the fourth range—in other areas there are six plates—two in both the second and third ranges. In the azygous area there are thirteen plates. The first one is heptagonal, in line with the first primary radials and fully as large as any of them. It is followed by three plates in the second range, five in the third range, three in the fourth range and one in the fifth range that unites with the plates of the vault. Our specimens do not disclose the vault and proboscis.

This species is distinguished by the numerous interradials and azygous plates, and by the order and arrangement of twenty-

two arms. The fourth primary radial in one of the rays is abnormal, or the commencement of development toward some other form, that is unknown, provided other specimens, in this species, do not retain the same character, in which case, it might be a specific character. We have the character preserved, only in the specimen that is illustrated.

Found in the Keokuk Group, at Boonville, Missouri, and now in the collection of S. A. Miller.

BATOCRINUS VENUSTULUS, n. sp.

Plate I, Fig. 7, azygous side of calyx and arms, a little depressed.

Species medium size. Calyx obconoidal, twice as wide as high; each radial series bears a low angular ridge from the basal plates to the free arms; interradial areas slightly flattened; surface granular; truncated for a medium-sized column.

Basals form an hexagonal disc one-third wider than the diameter of the column and having a height less than the distance from the column to the margin. First primary radials very little wider than high, upper face slightly arcuate for the reception of the second radials. Second primary radials quadrangular, more than twice as wide as high. Third primary radials pentagonal, a little larger than the second, about twice as wide as high, axillary, and support upon the upper sloping sides the secondary radials. On the distal side of the third primary radial, on the right of the azygous area there are four secondary radials, the last of which is axillary and supports upon each upper sloping side a free arm; on the proximal side there are two secondary radials, the last being axillary and supporting upon the distal side two tertiary radials and upon the proximal side three, the last ones supporting free arms, which gives to this ray four arms. In the ray on the left of the azygous area, the third primary radial supports, upon each upper sloping side, two secondary radials, the last being axiliary and the proximal series bears on the proximal side two tertiary radials and on the distal side two tertiary radials and an axillary plate that supports two arms; the distal series bears upon each upper sloping side two tertiary radials one of which bears an axillary plate that supports two arms. This arrangement gives to this ray six arms.

In each lateral ray the third primary radial supports upon each upper sloping side two secondary radials the last being axillary and bearing upon each upper sloping side three tertiary radials and an axillary plate which supports two arms, which gives to each of these rays eight arms. In the ray opposite the azygous area, there are three secondary radials followed by an axillary plate that supports two arms, in one series, and, in the other, there are three arms, which gives to this ray five arms. There are, therefore, in this species, thirty-two arms. The arms are composed of a double series of interlocking plates that show a slight tendency to flatten at the incurving superior ends, but not to be compared in this respect with *Batocrinus Sampsoni*. Pinnules long and dense.

In one of the interradial areas there are three plates, one followed by two smaller ones; in two of the areas there are four plates in each, one followed by two in the second range and one in the third; and in the other area there are five plates, one followed by two in the second range and two in the third. There are seven azygous interradials, the first one heptagonal, in line with the first primary radials and of about the same size. It is followed by three plates, the central one being larger than the lateral ones; and these by two plates, in the third range, and one in the fourth, that is somewhat elongated and reaches the plates of the vault. Vault conoidal, and sub central proboscis smaller than in *B. Sampsoni*.

This species will be distinguished by the arrangement of its thirty-two arms from all other species. The same tendency of the arms to flatten near the upper ends has been discovered in other species of *Batocrinus* that has been overlooked by authors. But where the flattening is as slight as in our specimens of this species, it is probable that other specimens will not show any flattening, and that the character is not even of specific importance, and, moreover, it is probable that it does not exist in younger specimens, which would again tend to destroy its importance.

Found in the Keokuk Group, at Boonville, Missouri, and now in the collection of S. A. Miller.

BATOCRINUS INSUETUS, n. sp.

Plate I, Fig. 8, azygous view of calyx, vault, proboscis and part of the arms; Fig. 9, side view of same specimen.

Species rather below medium size. Calyx obconoidal, truncated below, about twice as wide as high; surface smooth or finely granular. Column medium size.

Basals form an hexagonal disc one half wider than the diameter of the column, with a central depression and rim around it, for the attachment of the column. First primary radials wider than high. Second primary radials quadrangular, short, two or more times as wide as high. Third primary radials a little larger than the second, twice as wide as high, pentagonal, axillary, and support on the upper sloping sides the secondary radials. In each lateral ray, the third primary radial supports, upon each upper sloping side, two secondary radials, the last of which is axillary and supports upon each upper sloping side a tertiary radial, that bears a single arm. There are, therefore, four arms in each of these rays. The distal side of each third primary radial adjoining the azygous area supports three secondary radials that bear a single arm; the proximal side of each supports two secondary radials, the last of which is axillary and supports upon each side a tertiary radial that bears a single arm. There are, therefore, three arms to each of these rays. In the ray opposite the azygous area, the third primary supports upon each upper sloping side three secondary radials, the last of which supports a single arm. There are, therefore, sixteen simple arms in this species and sixteen ambulacral openings to the vault. The arms are rather small and composed of a double series of interlocking plates that are slightly deeper than wide, in the lower part, but the arms flatten out near the superior ends, as they do in many other species in this genus. Pinnules long and dense.

There are three regular interradials in each area, one large, the other two small. There are four azygous interradials, one heptagonal, in line with the first primary radials and slightly larger and longer than either of them. It is followed by three plates, the middle one being the larger and longer, but it is cut off from the vault by the tertiary radials. The vault is highly convex, with a large proboscis that terminates in a

balloon-shaped bulb, that has the azygous opening at one side of the summit. The plates of the vault are plain, or slightly convex, and smooth, but each plate, on the central and lower part of the balloon, bears a central tubercle, while the small plates on top and surrounding the orifice are smooth.

This species will be distinguished by the arrangement of its sixteen arms, by the four plates in the azygous area, and by the balloon-shaped proboscis. The shape of the vault and proboscis, in this genus, varies so much, that it may be doubtful about how far its form may be regarded as of even specific importance. We have among the species herein described the long slender proboscis extending beyond the arms, the balloon shaped proboscis, with arms capable of spreading all over it, and the convex vault, without proboscis, save a swelling area like a recumbent proboscis, with the azygous orifice below the ambulacral canals. The breaking up of the genus *Batocrinus*, on characters, based on the vault, azygous orifice, and superior part of the arms, into subgenera or distinct generic names does not seem to be practicable or natural.

Found in the Keokuk Group, at Boonville, Missouri, and now in the collection of S. A. Miller.

BATOCRINUS BROADHEADI, n. sp.

Plate I, Fig. 10, basal view azygous side up; Fig. 11, view opposite the azygous area.

Species full medium size and among the larger forms with which it is associated. Calyx somewhat hemispherical, in general outline, rather more than twice as wide as high; radial series forming low, angular ridges from the basal plates to the free arms; interradial areas gently rounded; arm openings directed nearly horizontally; sutures distinct; surface granular.

Basals form an hexagonal disc that expands a little beyond the angles of the radial ridges, and has a diameter two and a half times the diameter of the column, and a hemispherical depression in the truncated surface below, for the attachment of the column. First primary radials twice as wide as long, longitudinally angular in the central part. Second primary radials quadrangular, and varying from one and a half to two and a half times as wide as long. Third primary radials pen-

lagonal, larger than the second, wider than high, greatest width below the middle, at the angles formed by the junction of the lower expanding and upper sloping sides, axillary, and supporting on each upper sloping side the secondary radials. In the ray on the right of the azygous area, and in each lateral ray, there are two secondary radials, the second one of which is axillary, and bears upon each superior side two tertiary radials, which gives four arms to each of these three rays. In the ray on the left of the azygous area, there are two secondary radials, in the proximal series, the second one of which is axillary, and bears upon the proximal side two tertiary radials, and on the distal side one large tertiary radial, and in the distal series there are two secondary radials only, the last one being quite large. This gives to this ray three arms. In the ray opposite the azygous area the third primary radial bears upon each superior sloping side three secondary radials, which gives to this ray two arms. There are, therefore, seventeen arm openings to the vault in this species.

In the regular interradial area, between the three and four armed rays, there are only three plates, one very large followed by two elongated plates, one of which extends higher than the other. In each of the other three regular interradial areas there are four plates, one large plate, followed by two in the second range and one in the third. The azygous area is subovate in outline and contains nine plates. The first one is in line with the first radials, but smaller and narrower; it is followed by three much larger plates in the second range, and these by three in the third range, which are supported on two of the plates of the second range. Above the middle one in the third range there is a small plate, and between its right superior sloping side and the left superior side of the upper plate, in the third range, an elongated plate is supported that extends its superior angle between the second tertiary radials and unites with the plates of the vault.

Vault conoidal, slightly depressed in the interradial areas, and covered with rather large, polygonal, convex plates. Two small ovarian (?) apertures may be distinguished between the ambulacral openings in the azygous area; they are above the

tertiary radials, at the angles between the two vault plates, in the azygous depression, and the smaller plate at each side of the ambulacral canals. Proboscis unknown.

Found in the Keokuk Group at Boonville, Missouri, and now in the collection of S. A. Miller. The specific name is in honor of Prof. G. C. Broadhead, formerly State Geologist of Missouri, a gentleman of high scientific attainments, whose professional skill and untiring energy has to such a great extent contributed to our knowledge of the geology, as well as to the wonderful development of the mining and economical industries of that state.

BATOCRINUS NITIDULUS, n. sp.

Plate I, Fig. 12, azygous view of calyx and vault; Fig. 13, opposite view of same.

We have four specimens of this species of the same size and in the same state of preservation as the one illustrated. None of them show any of the arms.

Species below medium size. Calyx broadly truncated below and obconoidal above, or like the frustum of a cone; one-half wider than high. Plates convex, usually bearing a transverse angular ridge, and beveled from the central part to the sutures. No radial ridges. Column small and having a very small, round, columnar canal.

Basals form an hexagonal disc nearly twice as wide as the diameter of the column and having a height less than half the diameter of the column. First primary radials wider than high. Second primary radials quadrangular, about three times as wide as high. Third primary radials vary from pentagonal to heptagonal depending upon the number of interradials that each side abuts against, and they vary somewhat in size, but are about twice as large as the second radials, axillary, and support on each upper sloping side two secondary radials, the last one of which is axillary and supports on each upper sloping side a single tertiary radial. There are, therefore, four arm openings to the vault from each ray or twenty ambulacral openings to the vault. The probability is that the arms did not bifurcate and that the species had only twenty arms.

There are three regular interradials, in each area, one large the other two smaller and somewhat elongated, in the speci

men illustrated; but in other specimens in some of the areas, there are only two plates, one following the other. There are eight azygous interradials in the specimen illustrated, the first one heptagonal, in line with the first primary radials and of about the same size. It is followed by three plates, the middle one being the smaller, and these are followed by four smaller plates that are cut off from the vault by the union of the tertiary radials. In some of the other specimens, there are only three plates in the third range and, hence, only seven azygous plates. The vault is conoidal, covered with convex plates and bears an almost central proboscis.

This species is distinguished by its trim, neat form, beveled plates and twenty ambulacral openings to the vault. This is one of the forms that might be referred to ***Eretmocrinus***, if that were a valid genus.

Found in the Keokuk Group, at Boonville, Mo., and now in the collection of S. A. Miller.

BATOCRINUS PECULIARIS, n. sp.

Plate I, Fig. 14, azygous side view; Fig. 15, basal view; Fig. 16, summit view of the same specimen.

Species below medium size. Calyx somewhat obconcidal, but spreading upward canopy-like, and directing the ambulacral openings horizontally. Truncated nearly three times the diameter of the column; plates moderately convex; sutures plain; surface granular. Column small; canal cinque foil.

Basals form an hexagonal disc nearly three times the diameter of the column, concave centrally below for the attachment of the column, and having a height equal to about half the diameter of the column. First primary radials wider than high. Second primary radials quadrangular, three times as wide as high. Third primary radials pentagonal, larger than the second, nearly three times as wide as high, axillary and support on the upper sloping sides the secondary radials. On the distal side of each ray adjoining the azygous area there are three secondary radials, and on the proximal side two secondary radials, the last of which is axillary and bears upon each upper slopping side two tertiary radials, which gives to each of these rays three arms. One of the lateral rays is con-

structed in like manner and bears three arms. The other lateral ray bears upon each of the upper sides of the third primary radial two secondary radials, the last being axillary and supporting on each upper sloping side two tertiary radials, which gives to this ray four arms. In the ray opposite the azygous area there are three secondary radials, which gives to this ray two arms. There are, therefore, fifteen arms in this species, as shown by the ambulacral openings to the vault.

There are three regular interradials in each area, one large, the other two small and somewhat elongated. The azygous area is very peculiar, as the proboscis having the azygous orifice separates the tertiary radials and projects below the ambulacral openings and occupies nearly half the azygous area. The first plate is heptagonal, in line with the first primary radials and the largest plate in the body. There are three plates in the second range, the middle one being the smaller and supporting the plates that surround the azygous orifice. In the third range, on one side of the recumbent proboscis or azygous ridge, there is one rather large plate, and all the other plates in the area are small and form part of the round recumbent proboscis. The vault is highly convex, and has a capacity equal to or greater than that of the calyx. It is covered with small, convex, polygonal plates. Upon the azygous side of the center a convex elevation arises that becomes more defined as it passes down between the ambulacral orifices and finally projects, like the end of a proboscis, below the arms in the upper third of the azygous area. It appears like the recumbent proboscis in *Siphonocrinus armosus*, though not projecting quite as much. Probably the word "proboscis" should not be used in the definition, for it is merely a rounded ridge from one side of the vault that terminates in a hemispherical projection that bears an orifice in the upper part of the azygous area, as shown in the illustration.

This species is distinguished by its general form, convex vault, recumbent proboscis with orifice below the arms, and by its fifteen arms, from all other species. By some it might be referred to *Dorycrinus*, but we think it is clearly a *Batocrinus*. Found in the Keokuk Group, at Boonville, Missouri, and now in the collection of S. A. Miller.

BATOCRINUS IMPARILIS, n. sp.

Plate 1, Fig. 17, azygous view; Fig. 18, opposite azygous side

We have several specimens of this species varying from half the size of the one illustrated to about one-fourth larger. None of them show any of the arms, and the one illustrated is best preserved.

Calyx urn-shaped; about one-fourth wider than high, though sometimes nearly as high as wide. Plates tumid; no radial ridges; sutures distinct; column small; surface granular.

Basals form a very low hexagonal cup about three times as wide as the diameter of the column. The columnar facet is round, deep and preserves the serrated lines for the attachment of the column. The convexity of the plates extends below the point of attachment of the column. The first primary radials are much larger than any other plates in the body and have a height nearly equaling the width. Second primary radials quadrangular, about twice as wide as high. Third primary radials very little larger than the second, pentagonal, axillary, and support on each upper sloping side of three rays two secondary radials, which gives to each of these rays two arms. Each third primary radial adjoining the azygous area bears upon the distal upper side two secondary radials, the last one bearing a single arm, and upon the proximal side two secondary radials the last of which is axillary and bears upon each upper sloping side a single tertiary radial which gives to each of these rays three arms. There are, therefore, twelve arm openings to the vault in this species.

There are three regular interradials in each area, one large, the other two smaller, somewhat elongated, and unite with the plates of the vault. The azygous area is large. The first plate is in line with the first primary radials and of about the same size. It is followed by three rather large plates, in the second range, and these, by three small plates, in the third range, that unite with three plates that separate the arms and unite with the plates of the vault. The vault is convex and covered with convex polygonal plates. The proboscis is small and subcentral, but it is broken off close to the vault in all our specimens.

This species is distinguished by its general form, convex plates, union of interradials with the plates of the vault, and by having twelve arms. It cannot be mistaken for any other described species.

Found by R. A. Blair, in the Burlington Group, at Sedalia, Missouri, and now in the collection of S. A. Miller.

BATOCRINUS INCULTUS, n. sp.

Plate I, Fig. 19: azygous view; Fig. 20, opposite azygous side.

We have four specimens which we refer to this species, though there is some difference in the azygous areas. None of them show any arms. Species below medium size. Calyx urn-shaped and nearly as high as wide. Plates highly convex; no radial ridges; sutures distinct. Column round, rather large and having a cinque foil canal.

Basals form an elevated hexagonal cup about twice as wide as the diameter of the column and having an hemispherical depression below, for the insertion of the column. The first primary radials are the largest plates in the body, except the first azygous plate, and have a height nearly equal to the width. Second primary radials, quadrangular, and about or less than one-half wider than high. Third primary radials considerably larger than the second, and pentagonal or hexagonal, depending on the number of plates they abut upon, in the interradial areas, axillary, and support on each of the superior lateral sides two secondary radials, each of which bears a single arm. There are, therefore, ten arm openings to the vault, in this species.

The regular interradial areas are elongated and generally have four plates, but sometimes only three. There is one in the first range, generally two elongated plates in the second range, but sometimes only one, and one elongated plate in the third range that connects with the plates of the vault. The azygous area is large, and the number of plates is not uniform. The first plate is in line with the first primary radials and fully as large as any of them. It is followed, in the specimen illustrated, in the second range, by four plates, but, in other specimens, there are only three. Above these, in the speci-

men illustrated, there are three plates, followed by two plates that connect with the plates of the vault, but in other specimens only three or four plates can be distinguished.

The vault is convex and is covered by a few large convex plates, and bears a large subcentral proboscis, which is surrounded, near the base, by large convex plates.

This species bears some resemblance to *B. imparilis*, above described, but the calyx is more elongated, the vault and proboscis are altogether different, and it has only ten arms, while that species has twelve. When compared with other described species the differences are equally as well defined. We may here call attention to the fact, that the number of plates in the azygous and regular interradial areas, in the genus *Batocrinus*, is of less importance than the number of ambulacral openings to the vault, not only as shown by this species, but as shown by many others, in our possession.

Found by R. A. Blair, in the Burlington Group, at Sedalia, Missouri, and now in the collection of S. A. Miller.

BATOCRINUS INSPERATUS, n. sp.

Plate I, Fig. 21, azygous view; Fig. 22, opposite azygous side.

This species is founded upon a single specimen, that seems to be perfect in all its parts, and, if abnormal, we do not know from what parents it arose. The calyx and vault together have a sub-elliptical outline with both ends slightly truncated. Species below medium size. Calyx urn-shaped, about as high as wide. Plates tumid; no radial ridges; sutures distinct; surface granular. Column round and small. It has, however, only four radial series.

Basals form an elevated hexagonal cup, about twice as wide as the diameter of the column, and having, the plates rounded below to a hemispherical depression for the insertion of the column. First primary radials wider than high and of unequal size, though there are only four of them. Second primary radials quadrangular, and nearly as long as wide. Third primary radials considerably larger than the second, three hexagonal and one heptagonal, axillary, and support on each of the superior sloping sides two secondary radials, each of which bears a single arm. There are, therefore, eight arm openings to the vault in this species.

The first regular interradials are large, tumid plates, and, in one of the areas, the first one is followed by two elongated plates, that unite with two plates belonging to the vault, but, in the other two areas, the first one is followed by two plates in the second range and two smaller ones in the third range, that connect with two plates belonging to the vault. The first azygous plate is in line with the first primary radials, very tumid, and rather larger than either of them. It is followed by three plates in the second range, and these by two in the third range, that unite with the plates of the vault. The vault is elevated over the ambulacral canals, conical, and bears a large central proboscis, which is broken off in our specimen. The plates on the vault are polygonal, tumid and few in number.

This species cannot be compared with any other, unless it is for the purpose of showing that it is abnormal, and not entitled to a specific name It is four-fifths of a *Batocrinus*. It agrees with *Batocrinus* as far as it goes. The definition of *Batocrinus* requires five radial series, and this species has only four. The radial series that is missing is the one opposite the azygous area. Probably it will be found to be as near *B. incultus* as to any other species, but, aside from the four radial series, it will be noticed that the interradial and azygous areas and the vault and proboscis are quite different in the two species. Take from *B. incultus* one radial series and one interradial area and close up the opening, it will be found to be widely different from this species in general form and outline The differences are even more marked when compared with *B. imparilis*, which has twelve ambulacral openings. We see no reason why a crinoid should not have perpetuated itself while having only four radial series as well as if it had six. The difficulty that is hard to overcome in this case is, if we have here a good species, we ought also to have a good genus, and yet we are unwilling to take it out of the genus *Batocrinus*. If our specimen is abnormal, it is well worth defining and illustrating, and the specific name we have given it will serve for a handle until some one has ascertained to what species it should be referred, and even then the synonymy will not have altogether lost its usefulness. We are of the opinion that our specimen descended

from a *Batocrinus*, and, if we had two specimens, we would be confident that it could perpetuate itself and, therefore, rank as a species; but, if the single specimen is all that ever existed, we would say it is abnormal, and only proves the great vitality the species possessed, that gave it the strength to grow to maturity in the perfect form of its kind, while one-fifth of the body was absent from its birth or inception. Under all the circumstances, probably, the specific name should be received only provisionally.

Found in the Burlington Group, at Sedalia, Missouri, and now in the collection of S. A. Miller.

BATOCRINUS FORMACEUS, n. sp.

Plate I, Fig. 23, azygous view; Fig. 24, opposite view.

Species medium or above medium size. Calyx bowl-shaped, semi-elliptical, broadly rounded below; height two-thirds the diameter; no radial ridges; sutures distinct, not beveled; surface granular. Column small, round.

Basals form an hexagonal disc about twice as wide as the diameter of the column with an hemispherical columnar cavity radiately furrowed. First radials large, expanded, three hexagonal and two heptagonal. Second radials, quadrangular, a little wider than long. Third radials one-half larger than the second, pentagonal, except the one upon the left of the azygous area, which is hexagonal, and three of the rays support upon each upper sloping side two secondary radials, the last of which is axillary and supports upon each upper sloping side two tertiary radials which gives to each of these rays four arms. In one of the lateral rays there are upon one side three secondary radials and upon the other two secondary radials, the last being axillary and supporting upon each upper sloping side two tertiary radials, which gives to this ray three arms. In the ray opposite the azygous area the third primary radial supports, upon each superior side, three secondary radials, which gives to this ray two arms. There are, therefore, seventeen arm openings to the vault in this species.

The regular areas do not connect with the vault, except in the area between the two and three armed rays and the number of plates in each varies from three to five. The azygous

area is very large and contains fifteen plates. The first one is in line with the first primary radials and of the same size. It is followed by three plates in the second range, five plates in the third range, three in the fourth range and above these there are three plates two of which connect with the plates of the vault. Vault convex, composed of polygonal, convex plates and bears a strong subcentral proboscis.

This species is distinguished by its general form, absence of radial ridges, and seventeen ambulacral openings to the vault. It will also be distinguished by the number of plates in the azygous area, if that feature is of specific importance, but we have known the number of plates, in the azygous area, to vary, among specimens, that we have referred to the same species, and, probably, in this species some specimens may show a less number of plates, commencing with the five plates in the third range and continuing to the vault. We have seen two specimens besides the one illustrated, but the plates in the upper part of the azygous area are either not well preserved or are not to be distinguished from the type.

Found in the Burlington Group, at Sedalia, Missouri, and now in the collection S. A. Miller.

BATOCRINUS INCONSUETUS, n. sp.

Plate I, Fig. 25, basal view; Fig. 26, summit view; Fig. 27, azygous side view.

Species medium or below medium size. Calyx very low and saucer-shaped; height not more than one-fourth the diameter, and ambulacral openings directed horizontally; slight radial ridges, interradials plain; surface smooth. Column medium size and round.

Basals form a circular disc that projects below the first primary radials about the thickness of a plate, has a diameter about twice as great as the diameter of the column, and bears a concave, radiately lined depression for the columnar attachment. First primary radicals twice as wide as long, three hexagonal and two heptagonal. Second primary radials quadrangular, about three times as wide as long. Third primary radials a little larger than the second, twice as wide as long, pentagonal, axillary and in each lateral ray support upon each

upper sloping side two secondary radials, the last of which is axillary and supports upon each upper side two tertiary radials which gives to each of these rays four arms. Upon the distal side of the third primary radials adjoining the azygous area there are four secondary radials, and on the proximal side two secondary radials, the last of which is axillary and bears upon the distal side two tertiary radials, and upon the proximal side three tertiary radials which arrangement gives to each of these rays three arms. In the ray opposite the azygous area there are three secondary radials upon each side of the third primary which gives to this ray two arms. There are, therefore, sixteen ambulacral openings to the vault in this species, and the last radials are small and contracted which makes it probable that the arms, which are not preserved, are single and not large.

There are three regular interradials in each area, one followed by two in the second range that are short and enclosed below the tertiary radials so that they do not approach the vault. The first azygous plate is in line with the first primary radials and somewhat longer, and it is followed, in the second range, by four plates that very much widen the lower part of the area. There are four plates in the third range and these are followed by a single narrow elongated plate that connects with the plates of the vault.

The vault is low and has about the same capacity as the calyx. It is covered with polygonal, convex plates and bears a small subcentral proboscis. The ovarian apertures are conspicuous in this species. There are two between each pair of arms and one between the secondary and tertiary series in the three-armed rays, which makes sixteen in the species. They are above the calyx and connect with the ambulacral canals under the vault.

This species is distinguished by its general form, sixteen arms, four azygous plates in the second range, short regular interradial areas, and ovarian apertures. It cannot be mistaken for any other described species.

Found by S. A. Miller in the Keokuk Group, at Boonville, Missouri, and now in his collection.

BATOCRINUS SERRATUS, n. sp.

Plate I, Fig. 28, basal view; Fig. 29, azygous side view; Fig. 30, summit view.

Species medium or below medium size, the one illustrated is the largest among four which are before us. Calyx nearly flat; height one-fifth or one-sixth the diameter, and ambulacral openings directed horizontally; radial series project at the margin so as to notch the circumference at the interradial parts, and they are somewhat lobed, without radial ridges; surface granular. Column round, medium size.

Basals form a subhexagonal disc, that projects below the first primary radials about the thickness of a plate, has a diameter about one-half greater than the diameter of the column, and bears a slight concave, radiately lined depression, for the columnar attachment. First primary radials twice as wide as long, three hexagonal, two heptagonal. Second primary radials quadrangular and from two to three times as wide as long. Third primary radials a little larger than the second, twice as wide as long, pentagonal, axillary and in each lateral ray support upon each upper sloping side two secondary radials, the last of which is axillary and supports upon each upper sloping side two tertiary radials, which gives to each of these rays four arms. Upon the distal side of the third primary radials adjoining the azygous area there are three secondary radials, and on the proximal side, two secondary radials, the last of which are axillary and bear upon each superior sloping side two tertiary radials which gives to each of these rays three arms. In the ray opposite the azygous area there are three secondary radials upon each side of the third primary radial, which gives to this ray two arms. There are, therefore, sixteen ambulacral openings to the vault in this species.

The regular interradial areas are elongated and not uniform. In two of the areas one large plate is followed by one short small plate and one elongated plate that unites with two plates belonging to the vault. In another area there are two plates corresponding to the elongated plate just mentioned, and the last one unites with the plates of the vault, and in the other area there are only two plates, one following the other, and they are cut off by the third radials from uniting with the plates of

the vault. The first azygous plate is in line with the first primary radials and somewhat smaller; it is followed by three plates in the second range and two in the third range, that unite with the plates of the vault.

The vault, though low, has more capacity than the calyx. It is covered with polygonal, convex plates and bears a small subcentral proboscis. The ambulacral areas are convex and the interambulacral areas abruptly depressed at the interradial areas, so that the vault presents the same notched margin that belongs to the calyx. There are sixteen ovarian apertures, but they are small and situated close to the ambulacral openings and not as far back upon the vault as in *B. inconsuetus*.

This species when compared with *B. inconsuetus*, that has the same number of arms, will be found to have quite different interradial and azygous areas and fewer plates in them; there are fewer tertiary radials in the rays, and the lobed rays and depressed marginal interradial areas serve at once to distinguish it, without touching upon minor differences, that will occur to any one who reads the descriptions. It is so different from all other described species that no comparison with any of them is necessary.

Found by S. A. Miller in the Keokuk Group, at Booneville, Missouri, and now in his collection.

BATOCRINUS IGNOTUS, n. sp.

Plate I, Fig. 31, basal view; Fig. 32, azygous side view; Fig. 33, summit view.

Species medium size. Calyx low, three times as wide as high and ambulacral openings directed horizontally. Radial series rounded, most strongly convex at the margin; interradial areas slightly concave, surface granular; column round, medium size.

Basals form a subhexagonal disc that projects below the first primary radials and has a diameter about twice as great as the diameter of the column; it bears a moderately concave, radiately lined depression for the columnar attachment. First primary radials of unequal size and a little wider than long, three hexagonal, two heptagonal. Second primary radials quadrangular and about three times as wide as long. Third

primary radials larger than the second, more than twice as wide as long, pentagonal, axillary, and in one lateral ray supports upon each upper sloping side two secondary radials, the last being axillary and supporting upon each upper sloping side two tertiary radials; in the other lateral ray there are three secondary radials, on each side of the third primary radial, the last of which are axillary and bear upon each superior side two tertiary radials, which gives to each of these rays four arms. Upon the distal side of the third primary radials, adjoining the azygous area there are three secondary radials, and on the proximal side two secondary radials the last of which are axillary and bear upon each superior sloping side two tertiary radials, which gives to each of these rays three arms. In the ray opposite the azygous area the third primary radial bears upon one side three secondary radials and upon the other two secondary radials, the last being axillary and supporting upon each upper side two tertiary radials, which gives to this arm three rays. It will be observed that this ray is constructed in the same way that the rays are on each side of the azygous area and that the side having three secondary radials is on the side of the lateral ray that has three secondary radials on each side of the third primary radial. This species, therefore, has seventeen ambulacral openings to the vault.

There are three regular interradials in each area; one large plate followed by two small ones. They are below the tertiary radials and do not reach near the vault. There are six plates in the azygous area. The first one is in line with the first primary radials and about the same size; it is followed by three plates in the second range, and two in the third, neither of which approaches the vault.

The vault is highly convex and has more capacity than the calyx. It is covered with plain, polygonal plates, and bears a rather large proboscis. The ovarian apertures are small and on the sides of the plates surrounding the ambulacral canals. There appear to be seventeen of them.

This species is distinguished by its general form and seventeen arms. If the three secondary radials, in one of the lateral rays, is to be regarded as a normal feature, then that alone will distinguish it from all other species. If we had two

specimens of this species possessing three secondary radials, we would not hesitate to regard it as a normal feature, but having only one, it may be a strange freak that was not perpetuated.

Found by S. A. Miller in the Keokuk Group, at Boonville, Missouri, and now in his collection.

BATOCRINUS MODESTUS, n. sp.

Plate I, Fig. 34, basal view; Fig. 35, azygous side view; Fig. 36, summit view.

Species medium or just below medium size. Calyx subhemispherical, rather more than twice as wide as high, and broadly rounded below. Plates convex. No radial ridges. Surface granular. Column round, medium size.

Basals form an hexagonal disc that projects slightly below the first primary radials and has a diameter a little less than twice the diameter of the column; it bears a moderately concave, radiately lined depression for the columnar attachment. First primary radials about one-half wider than high, three hexagonal, two heptagonal. Second primary radials quadrangular, three or four times as wide as long. Third primary radials only a little longer than the second, and two or three times as wide as long, pentagonal, axillary, and in one lateral ray supports upon each upper sloping side two secondary radials, the last one of which is axillary and supports upon each upper sloping side two tertiary radials, which gives to this ray four arms. In the other lateral ray there are four secondary radials upon one side of the third primary radial and two upon the other followed by three tertiary radials upon each side, which gives to this ray three arms. Upon the distal side of the third primary radials adjoining the azygous area there are four secondary radials and on the proximal side two, the last being axillary and bearing upon each upper sloping side two or three tertiary radials which gives to each of these rays three arms. In the ray opposite the azygous area there are three secondary radials on each upper sloping side which gives to this ray two arms. There are, therefore, fifteen arm openings to the vault, in this species, but all the arms preserved in any of our specimens at once bifurcate, giving, as indicated, thirty free

arms to the species. We have, however, only three specimens showing any of the arms, but one of them has five bifurcating rays showing part of ten arms. The general form and parts preserved leave little doubt that the species has thirty free arms.

There are three regular interradials in each area—one large plate followed by two small ones. They are below the tertiary radials and do not reach the vault. There are seven plates in the azygous area. The first one is in line with the first primary radials and of about the same size; it is followed by three plates in the second range, two in the third range and one in the fourth, which unites with the plates of the vault.

The vault is conoidal and has a capacity about equal to that of the calyx. It is covered with plain and slightly convex, polygonal plates, and bears a moderate-sized subcentral proboscis. No ovarian pores have been seen in any of our specimens and there appears to be no evidence of their existence.

This species is distinguished by its general form, hemispherical calyx and conoidal vault, fifteen ambulacral openings to the vault and thirty free arms. Any one capable of distinguishing a *Batocrinus* will at once know the species from these peculiarities.

Found by S. A. Miller, in the Keokuk Group, at Boonville, Missouri, and now in his collection.

BATOCRINUS HETEROCLITUS, n. sp.

Plate I, Fig. 37, basal view; Fig. 38, azygous side; Fig. 39. summit view.

Species rather below medium size. Calyx and vault subequal, and together somewhat trochiform. Height of the calyx about one third the diameter, and ambulacral openings directed horizontally. Radial series project at the margin, so as to notch the circumference at the interradial parts. Radial ridges well defined and angular. Surface granular. Column round and small.

Basals form an hexagonal disc or very low cup two and a half times the diameter of the column. First primary radials wider than long, three hexagonal, two heptagonal. Second primary radials quadrangular, and from two to three times as

wide as long. Third primary radials only a little larger than the second, twice as wide as long, pentagonal, axillary, and in each lateral ray, and in the ray on the right of the azygous area support upon each upper sloping side two secondary radials, the last of which are axillary and support upon each upper sloping side two tertiary radials, which gives to each of these three rays four arms. The ray on the left of the azygous area bears on the distal side of the third primary radial three secondary radials, and on the proximal side two secondary radials, the last one being axillary and supporting, on each upper sloping side, a single tertiary radial, which gives to this ray three arms. The ray opposite the azygous area bears upon each upper side three secondary radials, which give to it two arms. There are, therefore, seventeen arm openings to the vault in this species.

The regular interradial areas are elongated and connected with the vault. The first plate is smaller than a first radial; it is followed by two plates in the second range, and, in some areas, with two plates in the third range that connect with the plates of the vault, and, in other areas, one plate in the third range connects with the plates of the vault. There are, therefore, four plates in some areas and five in other areas. The azygous area is large and connected with the plates of the vault. The first azygous plate is in line with the first primary radials and somewhat narrower; it is followed by three large plates in the second range, three smaller ones in the third range, and two in the fourth range, that connect with the plates of the vault. There are, therefore, nine plates in this area.

The vault is conoidal, low, depressed toward the margin in the interradial areas, and covered with polygonal, convex plates. There is doubt about the presence of a proboscis. The highest elevation is almost central and if a proboscis existed it must have been very small, for, at that place, the plates indicate a small orifice, without the upright plates that support a proboscis. We think no proboscis existed, in this species, and, therefore, we think, in *Batocrinus*, all the variations may exist on the vault, from no proboscis at all, to the balloon-shaped or to the most elongated and crooked forms

that have been called *Eretmocrinus*. A few ovarian apertures may be distinguished, but they are very minute, and, adjoining some of the arms, there seems to be none at all; in fact, there are only two, one on each side of the azygous depression, that can be clearly distinguished.

This species will be distinguished, by its general form, connection of the interradial area with the vault, and by the seventeen ambulacral openings. The entire absence of a proboscis or the existence of a very short one is a feature also of some importance.

Found by S. A. Miller in the Keokuk Group, at Boonville, Missouri, and now in his collection.

BATOCRINUS PROCERUS, n. sp.

Plate I, Fig. 40, basal view; Fig. 41, azygous side view; Fig. 42, opposite view of same specimen.

Species medium size and capacity of the vault exceeding that of the calyx and belonging to those forms which are referred by authors to *Eretmocrinus*. Calyx broadly truncated below and obconoidal above, for a short distance, but becoming obpyramidal, in the region of the arms, by reason of a slight tendency toward lobes, in the radial series. No radial ridges. Width about one-half more than height. Plates moderately convex. Column round not large.

Basals form an hexagonal disc more than one-half wider than the diameter of the column, with a concave, radiately lined depression below, for the columnar attachment. First primary radials wider than high. Second primary radials quadrangular, from two to three times as wide as high. Third primary radials about one-half larger than the second, more than twice as wide as long, pentagonal, axillary, and, in each series, except the one opposite the azygous area, bear upon each upper sloping side two secondary radials, the last one of which is axillary and supports upon each superior sloping side a single tertiary radial, which gives to each of these four rays four arms. In the ray opposite the azygous area there are, upon one of the superior sloping sides of the third primary radial, three secondary radials and upon the other two secondary radials, the last of which is axillary and

bears upon each upper side, a single tertiary radial, which gives to this ray three arms. There are, therefore, nineteen arms in this species.

There are three regular interradials, in each area, one large followed by two smaller ones, below the tertiary radials, which abut against each other and cut off the area from any connection with the vault. There are seven plates in the azygous area. The first one in the line with the first primary radials and somewhat narrower; it is followed by three plates in the second range and two in the third and above these one plate that unites with the plates of the vault, as it appears in our specimen. Our specimen, however, is slightly injured about the top of this plate, so as to leave the sutures in doubt, and possibly an angle from the tertiary radials may separate it from the plates of the vault.

The vault is somewhat pyramidal in the lower part and conoidal above. On the azygous side there is a longitudinal, concave depression extending down to the azygous area of the calyx. The vault is covered with slightly convex, polygonal plates. The proboscis is large and central. There are no ovarian pores.

This species is distinguished by its general form and nineteen ambulacral openings to the vault. It is unnecessary to compare it with any other species that possessed the same number of ambulacral openings.

Found by S. A. Miller, in the Keokuk Group, at Boonville, Missouri, and now in his collection.

BATOCRINUS VICINUS, n. sp.

Plate II. Fig. 1, basal view; Fig. 2, azygous side view; Fig. 3, summit view.

Species below medium size, vault rather larger than the calyx, but, on the whole, somewhat trochiform. Height of the calyx less than half the diameter, and ambulacral openings directed horizontally. Radial series project at the margin so as to notch the circumference at the interradial parts. Radial ridges moderately well defined and angular. Surface, granular. Column round and small.

Basals form an hexagonal disc about one-half wider than the diameter of the column, and which extends, in a low rim, below the first radials. First primary radials wider than long, three hexagonal, two heptagonal. Second primary radials quadrangular, and about twice as wide as long. Third primary radials about twice as large as the second, and about twice as wide as long, pentagonal, axillary, and each one, adjoining the azygous area, bears on the distal side two secondary radials and on the proximal side two secondary radials, the last being axillary and supporting upon each upper side a single tertiary radial which gives to each of these rays three arms. Each lateral ray is constructed in the same manner and each bear three arms. In the ray opposite the azygous side the third primary radial bears upon each upper sloping side three secondary radials, which gives to this ray two arms. There are, therefore, fourteen arms in this species.

The interradial areas are elongated and the plates connect with those of the vault. The first plate is about the size of a first primary radial; it is followed by two small plates in the second range, and one or two in the third range, and these by one or two that connect with the plates of the vault. There are, in these areas, from five to seven plates. The azygous area is large and contains twelve plates. The first one is in line with the first primary radials and of about the same size; it is followed by three plates in the second range, four in the third range, and four in the fourth range, three of which connect with the plates of the vault.

The vault is highly convex centrally and depressed toward the margin, in the interradial areas, and covered with polygonal convex plates. A large plate occupies the central part of the vault, and adjoining it on the azygous side is a small azygous orifice directed upward. There is no proboscis, though the plates surrounding the orifice are elevated higher than the central plate. There are no ovarian apertures.

This species is distinguished by its general form and fourteen arms from all other species. By some it will be classed in the genus *Dorycrinus*, but we are not inclined to extend the genus *Dorycrinus* to include such species as this, for by so doing it will graduate into *Bulocrinus*. In *Dorycrinus* there are

large plates bearing spines on the vault, and the azygous area is altogether different from the regular interradial areas, and the orifice is directed laterally from a more or less bulbous protuberance, neither of which characters exist in this species. It is true, however, that, in some respects, this species is allied to *Dorycrinus*, and is widely different from the most typical *Batocrinus* in some respects, but the essential characters enable us, without hesitation, to refer it to the latter genus.

Found in the Keokuk Group, at Booneville, Missouri, and now in the collection of S. A. Miller.

BATOCRINUS INOPINATUS, n. sp.

Plate II, Fig. 4, basal view; Fig. 5, azygous side; Fig. 6, summit view.

Species below medium size. Calyx short, obconoidal, diameter more than twice the height. Radial ridges present, but not very well defined. Surface granular. Column round and quite small.

Basals form an hexagonal disc or very low cup that bears a rim below the first primary radials, and has a diameter about twice as great as the diameter of the column. First primary radials a little wider than long, three hexagonal, two heptagonal. Second primary radials, quadrangular, very short, between two and three times as wide as long. Third primary radials one half larger than the second, three pentagonal, two hexagonal, axillary, and each one adjoining the azygous area bears, on the distal side, two secondary radials, and one of them bears, on the proximal side, a single secondary radial which is axillary, and bears upon each upper sloping side a single tertiary radial, and the other one bears, on the proximal side, two secondary radials, the last one of which is axillary, and bears upon one upper sloping side two tertiary radials, and upon the other, one, giving to each of these rays three arms. One of the lateral rays bears upon one of the superior sloping sides of the third primary radial three secondary plates, and upon the other two secondary radials, the last of which is axillary, and bears upon each upper side a single tertiary radial, which gives to this ray three arms. In the other lateral ray the third primary radial bears upon each upper sloping side

two secondary radials, the last being axillary, and bearing upon the proximal sides one tertiary radial, and upon the distal sides two tertiary radials, which gives to this ray four arms. In the ray opposite the azygous area the third primary radial bears upon each upper sloping side three secondary radials, which gives to this ray two arms. There are, therefore, fifteen arm openings to the vault in this species.

The interradial areas connect with the vault, but they differ in form and in the number of plates. The first plate is about as large as a first primary radial. It is followed in one of the areas by a single plate, in two of the areas by two plates, and in one of the areas by three plates in the second range. In the third range in each case a single elongated plate connects with the plates of the vault. The azygous area is large, and contains ten plates. The first one is in line with the first primary radials, and is followed by three large plates in the second range. One of the lateral plates, in the second range, supports two small plates, and, over the middle plate, in the second range, there are two ranges of two plates each, one of the larger of which connects with the plates of the vault.

The vault is nearly flat, covered with slightly convex, polygonal plates, and bears a small subcentral proboscis. No ovarian aperatures can be distinguished.

This species is distinguished by its general form, flattened vault, peculiar interradial areas and fifteen arms.

Found by S. A. Miller, in the Keokuk Group, at Boonville, Missouri, and now in his collection.

BATOCRINUS PLANUS, n. sp.

Plate II, Fig. 11, basal view of a cast preserving elevated lines outlining the plates; Fig. 12, summit view of same specimen, but the outline of the plates is not preserved; Fig. 13, azygous side view of same; Fig. 14, basal view of another, perfectly preserving the plates, as far as illustrated.

Body very much depressed, pentagonal, capacity of the vault equal to or exceeding that of the calyx. Calyx very low, about four times as wide as high, concave in the region of the basals and gently rounding over the first radials toward the margin. Plates convex and radial ridges lobed above the first

radials. Surface granular. There are pits at the angles of the larger plates in our specimen, but that character is not shown on either of two casts and may not, therefore, be normal. One cast is one-fourth larger than the specimen illustrated. It will be observed, that there is some difference, in the proportional size of the plates, and the depressions on the cast, this is because the internal sides of the plates are not like the external surface. It is for this reason, that we cannot always recognize the casts, when we are conversant with specimens having the plates well preserved, and it is, therefore, a matter of gratification to be able to illustrate a species preserved in both ways.

The basals form a small hexagonal, concave disc which is almost wholly covered with the column. The first radials are quite as long as wide and very slightly rounded from the basals to the second radials, three hexagonal, two heptagonal. Second radials quadrangular, about one and a half times as wide as long. Third radials one-half larger than the second, pentagonal, axillary and support upon each upper sloping side two secondary radials, the last of which are axillary and support the free arms. As near as can be ascertained, from our specimens, there are four arms in each series, which arise from the second secondary radials and are directed horizontally.

The interradial areas are wide and the plates connect with those on the vault. In each regular area there are three plates, one large followed by two elongated plates that unite with three plates belonging to the vault. There are seven azygous interradials, the first one heptagonal, in line with the first primary radials and of the same size. It is followed by three plates in the second range and three in the third range, which unite with four plates belonging to the vault. The vault is convex, and bears a subcentral azygous prominence, with the orifice on top, but whether or not there is a proboscis cannot be determined definitely from our specimens.

This species would be classed with *Steganocrinus* if it had hexagonal, second, primary radials. But, aside from the unusual, flattened, pentagonal outline, the calyx is that of a true *Batocrinus*. There is no species described in either genus, with which it is necessary to compare it.

Found by R. A. Blair, in the Burlington Group, at Sedalia, Missouri, and now in the collection of S. A. Miller.

BATOCRINUS PRODIGIALIS, n. sp.

Plate III. Fig. 4, basal view; Fig. 5, azygous side; Fig. 6, summil view.

Species very large and wonderfully strong, nearly four times as wide as high. Exceedingly rough, by reason of the plates being produced in wedge-shaped, transverse nodes. The radial series are prolonged beyond the interradial areas leaving the circumference deeply notched between the arms. Column round at the calyx, large and pierced by a round columnar canal.

Basals short, projecting in cuneiform edges and expanding below the end of the column, and beveled at the sutures, so as to give the base an hexagonal outline. The basal disc is about twice as wide as the diameter of the column. The circle for the attachment of the column is only slightly concave and is radiately furrowed at the margin. First radials full twice as wide as high, three hexagonal, two heptagonal. Second primary radials, less than half as large as the first, quadrangular, and more than twice as wide as long. Third primary radials a little larger than the second, short, pentagonal, axillary and support on each upper sloping side two secondary radials, the last of which is axillary and bears the tertiary radials. In each of the radial series, there is upon one of the upper sloping sides of the last secondary radial a single tertiary radial which is axillary and bears upon each upper side quaternary radials, which gives to each ray five arms. In each radial series there are three or four tertiary radials and where the last tertiary radial is axillary there are upon each upper sloping side three quarternary radials. There are, therefore, twenty-five ambulacral openings to the vault. They are all directed horizontally so as to leave deeply notched interradial areas that connect with the vault.

Interradial areas elongated and covered with four plates. The first one is large and nearly as long as wide; it is followed by two plates in the second range and one in the third that connects with the plates of the vault. In the azygous area there are twelve plates. The first one is in line with the first primary radials and somewhat smaller; it is followed, in the second range, by three plates, in the third range by four plates, and in the

fourth range by four plates that connect with the plates of the vault. There is some irregularity in the last range of plates and two of them are elongated and in part belong to the vault. The fact is, that there is no line directly separating the plates of the calyx, in this area, from those belonging to the vault.

Vault abruptly convex on the azygous side and highly convex on the other, so that the vault has two or three times the capacity of the calyx. The vault is not depressed in the interradial areas, but carries its convexity full to the margin of the interradial areas of the calyx. It is covered with large polygonal nodose plates and bears a large, subcentral proboscis.

The expanded basals and large subcentral proboscis will cause it to be classed with *Eretmocrinus*, by many authors. The union of the interradial areas with the vault is not a common character of *Batocrinus*, but this is not a special character ascribed to *Eretmocrinus*, and if it were, still it is a character possessed by many species of *Batocrinus*. On the whole, the quadrangular second primary radials ally it with *Batocrinus* so strongly, that we have no hesitation in referring it to that genus. It is in striking contrast with the *Batocrinus* figured on Plate I of this Bulletin, and shows the wonderful development of this genus. This species is distinguished from *B. yandelli*, which it most resembles, by having twenty-five instead of twenty-one or twenty-two arm openings to the vault, and by having one more regular interradial in each area and one or two more azygous plates. The calyx is not as high, though it is a larger species.

Found by Geo. K. Greene, in the Keokuk Group, at Button Mould Knob, Kentucky, and now in the collection of Wm. F. E. Gurley.

SHUMARDOCRINUS, n. gen.

This genus is founded upon the species described by Shumard, under the name of *Actinocrinus concinnus*, in the Geo. Sur. of Mo. for 1855, page 189, and illustrated on plate A, figure 5. The generic formula is as follows: Basals, 3. Radials, 2 by 5. Regular interradials, 1. Azygous interradials, 3. Interradial areas connect with the vault without any distinguishing line of separation. Azygous oritice subcentral. No proboscis. Type *Shumardocrinus concinnus*.

The specific description given below may embody generic characters, but as we have only one species belonging to the genus, it is not easy to distinguish characters that are specific

from those that are generic; and, it is not improbable, that another species may be found having a proboscis, and, if so, the presence or absence of a proboscis will dwindle to specific importance only. We refer the genus to the *Actinocrinidæ*.

SHUMARDOCRINUS CONCINNUS, Shumard.

Plate II, Fig. 7, basal view; Fig. 8, summit view; some of the plates are destroyed; Fig. 9, side view; Fig. 10, azygous side view.

This species was described in 1855 by Shumard in these words:

"The portion of the body of this species situated above the second radial pieces is unknown.

"The inferior part of the calyx is nearly hemispherical, and the plates moderately thick. Basal pieces, three, nearly equal in size, forming a low cup with a nine-sided border, and presenting beneath a wide, circular, shallow depression for the column. First radials, moderately convex, length and breadth nearly equal, three hexagonal and two heptagonal; inferior angle of heptagonal pieces corresponding with a basal suture. Second radials, wider than long, with the articular facets for third radials nearly perpendicular, large, reniform, occupying nearly half the length and two-thirds the width of each piece. First interradials, hexagonal, a little longer than wide, and rather larger than the second radials. First areal pieces, hexagonal, longer than wide, its inferior angle corresponding to a basal suture. Second areals, heptagonal, surface of the plates ornamented with prominent radiating ridges, which rise from near the center of the plates, and cross the sutures, so as to form several sets of double triangles around the body."

It will be observed, that Shumard thought he had only a fragment of the calyx, whereas he had, in fact, a complete calyx. He thought he had an *Actinocrinus*, as far as the second radials, and that the third radials had been broken away, but he had a new genus that never had any third radials.

Meek and Worthen described *Actinocrinus validus*, in 1860, in proceedings Acad. Nat. Sci. Phil. p. 384; but in 1866, in vol. 2 of the Geo. Sur. Ill., p. 200, referred it to *Actinocrinus concinnus*. Their species has but little resemblance, in any respect, to Shumard's, and it is not easy to understand why

the two were ever confounded with each other. *Actinocrinus validus* must be restored, as a species, and as it is not a typical *Actinocrinus,* but approaches *Steganocrinus*, to which genus it has been referred by some authors, it may be known as *Steganocrinus validus*, Meek and Worthen.

We would describe this species from a specimen found in the Burlington Group, at Sedalia, Missouri, and illustrated in this Bulletin, as follows:

Calyx and vault subequal in capacity. Calyx pentagonal, three or four times as wide as high. Plates pyramidal and radiately sculptured. Column small and round.

Basals three and forming an hexagonal sculptured disck. First radials about as long as wide, three hexagonal and two heptagonal. Second radials about as large as the first, hexagonal and notched on the superior side by the ambulacral furrow. The articulating facets described by Shumard for the third radials are the articulating facets for the first plate in the free arms.

The first regular interradial hexagonal, smaller than the radials and succeeded by two smaller plates that abut upon the second radials and upon the ambulacral furrows and unite with three plates on the vault. The first azygous plate is in line with the first radials and of about the same size. It is followed by two plates, each of which is about the size of the first regular interradials. These plates abut the first plate on the sides of the ambulacral furrows, and are followed by three plates belonging to the vault.

The vault is convex and covered with highly convex and conical, polygonal plates. The azygous orifice is rather large and subcentral. The arms are unknown.

Found by R. A. Blair in the Burlington Group, at Sedalia, Missouri, and now in the collection of S. A. Miller.

MEGISTOCRINUS ORNATUS, n. sp.

Plate II. Fig. 15, basal view azygous side up: Fig. 16, azygous side view; Fig. 17, summit view.

Species medium or above medium size. Calyx subhemispherical, a little concave below, about twice as wide as high, not constricted below the arms. Surface delicately and ra

diately sculptured from the central part of each plate, but without any central nodes or other elevations. Arm openings directed upward at an angle of about forty-five degrees. Column round, rather large and having a large, slightly cinque-foil canal.

Basal plates form an hexagonal disc about one-third wider than the diameter of the column. The first primary radials are the largest plates in the calyx, slightly unequal in size, not visible in a side view, those abutting on a single basal are heptagonal. The second primary radials are hexagonal, wider than long, differ somewhat in size, but smaller than the first. The third primary radials are slightly smaller than the second, the two adjoining the azygous are hexagonal, the other three are heptagonal. They are all axillary and bear the secondary radials. There is a single secondary radial on each upper sloping side of the third primary radials in the two rays adjoining the azygous area and in the ray opposite thereto. Each of these secondary radials are axillary and bear upon each superior sloping side two tertiary radials which gives to each of these three rays four arms. In the two lateral rays there are three secondary radials in each series which gives to each of these rays two arms. This arrangement gives to the species sixteen arms.

In each of the intersecondary areas that separate the three four armed series there are two plates, one following the other, the second one unites with the plates of the vault which throws the arms together in eight pairs. In each regular interradial area there are ten plates, the first one is hexagonal, rests between the upper sloping sides of the first primary radials, separates the second primary radials and is followed by two smaller plates in the second range, three in the third range, two in the fourth range and two in the fifth range, that separate the last tertiary radials and unite with the plates of the vault. The azygous area is large and contains twenty two plates The first one is in line with the first primary radials and about as large; it is followed by three plates in the second range, five plates in the third range, four plates in the rourth range, four plates in the fifth range, three in the sixth range, and two in the seventh range that separate the last tertiary radials and unite with the plates of the vault,

The vault is highly convex in the central part and over the ambulacral channels and depressed toward the margin in the interambulacral areas. There is a large spine bearing plate in the center of the vault and one over the junction of the ambulacral canals in each of the five radial series. The other plates of the vault are polygonal, not tumid or spinous, but radiately sculptured after the manner of those forming the calyx. The plates are generally small and the sculpturing is so delicate and the sutures so indistinct that the artist found it impracticable to represent these characters in the illustrations. The azygous opening is large, subcentral, elevated and surrounded, at the base, with numerous small plates.

The general form and number of plates in the secondary and tertiary series will at once distinguish this species from *M. expansus*, and it is so different from all other sixteen armed species, that no comparison with any of them is necessary. It is a marked and beautiful species.

Found in the Hamilton Group, in Clarke county, Indiana, and the one figured is now in the collection of S. A. Miller, while there are four specimens in the collection of J. F. Hammell, of Madison, Indiana, and many more than that in the collection of Wm. F. E. Gurley, varying from one-fourth the size of the specimen illustrated, to more than twice its dimensions.

MEGISTOCRINUS HEMISPHERICUS, n. sp.

Plate II, Fig. 18, basal view azygous side up; Fig. 19, azygous side view; Fig. 20, summit view.

Species medium size. Calyx subhemispherical, broadly flattened below, a little more than one-half wider than high, not constricted below the arms. Arm openings directed upward at an angle of forty-five degrees. Surface in our specimens apparently smooth, without any tumid plates, though as our specimens are silicified, the granules, if any, are destroyed. Column large and having a large canal. The sutures are nearly all obliterated, in our specimens, above the third primary radials rendering a technical description of the plates above the third primary radials impracticable

The basal plates are substantially covered by the end of the column. The first primary radials are rather large, slightly unequal in size, directed from the column nearly horizontally, and those abutting on a single basal plate are hexagonal and those abutting upon two basals are heptagonal. The second primary radials are hexagonal, differ in size and are about as large as the first. The third primary radials are smaller than the first or second, three are pentagonal and two are hexagonal. They are axillary and bear the secondary radials. Two of the lateral rays have no tertiary radials and therefore have only two arms each. The ray on the left of the azygous area has four arms; the ray on the right of the azygous area has three arms and the ray opposite the azygous area has three arms. This arrangement gives to the species fourteen arms.

In the regular interradial areas there is one hexagonal plate separating the second primary radials, and two plates in the second range separating the third primary radials, each of which is about the size of the primary radials; above these plates the sutures are not distinct. The azygous area is large and protuberant, at the third and fourth ranges of plates. The first azygous plate is in line with the first primary radials and nearly as large; it is followed by three plates in the second range and by five plates in the third range, all of which are subequal in size; above these plates the sutures are not distinct in our specimen, but there seems to be five plates in the fourth range.

The vault is only moderately convex over the ambulacral areas, and rather slarply depressed toward the margin in the interambulacral areas. There is a tumid plate in the center and an azygous opening adjoining it. The sutures are destroyed in our specimen. There are no spinous plates over the ambulacral canals. This species is distinguished by its general form and fourteen arms.

Found in the Hamilton Group, in Clarke county, Indiana, and now in the collection of Mr. J. F. Hammell.

ACTINOCRINUS ALBERSI, n. sp.

Plate II, Fig. 21, azygous side; Fig. 22, apposite view; Fig. 23, summit view.

Species medium or above medium size. Calyx obconoidal, from one-third to one-half wider than high; plates convex and the larger ones sculptured so as to be more or less pyramidal, angles slightly depressed. No radial ridges. Column medium size.

Basals very short and project almost their entire length below the end of the column. They are beveled at the sutures so as to give the base a subhexagonal outline. The cicatrix for the attachment of the column is nearly or quite flat. First radials wider than long, three hexagonal, and two heptagonal, widening from the base to the lateral angles and contracting above. Second radials from one-fourth to one-half smaller than the first, hexagonal, and wider than high. Third primary radials a little smaller than the second, pentagonal, axillary, and support on each upper sloping side a single secondary radial, which is axillary, and, in three of the rays, support on each upper sloping side a tertiary radial, which gives to each of these rays four arms. In each ray adjoining the azygous area, there is, on the distal side of each third primary radial, a secondary radial, that supports upon each upper sloping side a single tertiary radial; but the secondary radial on the proximal side of the third primary radial bears upon its distal side an axillary tertiary radial, that bears upon each upper sloping side a quarternary radial, and upon its proximal side two tertiary radials, which gives to each of these two rays five arms. There are, therefore, twenty two ambulacral openings to the vault, in this species.

The regular interradial areas do not connect with the plates of the vault. In each of three of the areas there are five plates, one, followed by two in the second range and two in the third range; but in the other area there are six plates, one, followed by two in the second range, and two in the third range, and one small plate, in the fourth range. We do not suppose, however, that this slight difference, in the interradial areas, is of specific importance, and describe it only because our specimen is so constructed. The azygous area con-

nects with the vault and contains eleven plates. The first one is in line with the first primary radials though much smaller; it is followed by two plates in the second range, one of which is larger than it is. There are four plates in the third range that gives to the area a width nearly as great as the length. There are three plates, in the fourth range, that are followed by a single plate in the fifth range, that connects with a singe plate belonging, at least in part, to the vault. An ovarian pore is at a lateral angle of the last mentioned plate, which shows that it should be classed with the vault plates rather than with those of the calyx. There is a single, small, intersecondary plate in the area between the two arms and the three arms in each ray adjoining the azygous area.

The vault is elevated above the ambulacral openings, convex, and bears a central proboscis. It is covered by numerous polygonal, convex or spinous plates. It is not concave in the regular interradial areas, but is concave toward the margin in the azygous area. There are fourteen ovarian apertures, two separating the two arms from the three arms belonging to each ray adjoining the azygous area and two between the ambulacral openings belonging to each of the five radial series.

The specimen upon which this species is founded was collected by R. A. Blair, at Sedalia, Missouri, and was presented by him to S. A. Miller, among other fossils from the Chouteau limestone of that locality, several years ago. It has the light lead color of the Chouteau fossils and that of light yellowish color of the fossils from the Burlington Group of that locality. Were it not the color of the fossil itself, we might suppose that it is from the Burlington Group, and that it had accidently fallen in with the Chouteau fossils. But the rock is evidently the same as that in *Actinocrinus (?) Chouteauensis*, collected by Mr. F. A. Sampson and in other crinoids described from the Chouteau limestone of Sedalia. It does not seem to have any near affinity with any other crinoid from rocks of the age of the Chouteau, nor is it near enough specifically, to any described form from the Burlington Group to require any comparison for the purpose of pointing out differences. We have

no doubt that it is from the Chouteau Group. The specific name is in honor of Mr. A. Albers, of Cincinnati, Ohio, who did the drawing for this bulletin, and who is a good palæontologist as well as an excellent artist.

STROTOCRINUS BLAIRI, n. sp.

Plate II, Fig. 24, lateral view, some of the sutures obscure at the canopy.

Species medium size. Calyx below the canopy obpyramidal, truncated little, if any, beyond the size of the column, width about one-half more than the height. Plates convex, the larger ones bearing a central node, from which the plates are radiately sculptured. Radial ridges on the lower side of the canopy or projecting summit, but not distinguishable below the third primary radials.

Basals form a very low cup or rim more than four times as wide as high; sutures beveled; facet for the attachment of the column concave. First primary radials a little wider than high, three hexagonal, two heptagonal. Second primary radials about half as large as the first, wider than long, hexagonal. Third primary radials nearly as large as the second, wider than long, heptagonal and supporting on each upper sloping side a single secondary radial, which is axillary and supports on each upper sloping side the tertiary radials. As far as the sutures can be determined in our specimen, where there is a single tertiary radial in any series, it is axillary and bears quaternary plates, but where there are two or more tertiary plates in the series the last one is not axillary. The rays on each side of the azygous area have each six arm openings to the vault, and one of the lateral rays has the same number and the other two rays as far as preserved indicate the same number. It is, therefore, believed, that there are thirty arm openings to the vault.

The regular interradial areas are elongated and cut off from the vault by the tertiary and quaternary plates. There are eight plates in each area, one in the first range, two in the second, two in the third, two in the fourth and one in the fifth. The azygous area is also cut off from the vault by the quaternary plates. The first plate is in line with the first

primary radials and nearly as large, it is followed by two plates in the second range, four in the third, four in the fourth and above these there are three or more small plates but the sutures are too indistinct in our specimen to definitely determine the number.

The vault is quite convex and bears a central proboscis. It is covered with numerous, highly convex, polygonal plates.

This species is so well marked that it is unnecessary to compare it with any hitherto described.

Found in the Burlington Group, at Sedalia, Missouri, by R. A. Blair, in whose honor we have proposed the specific name, and now in the collection of S. A. Miller.

ACTINOCRINUS FOVEATUS, n. sp.

Plate II, Fig. 25, azygous side; Fig. 26, view opposite the azygous area of another specimen, the calyx is a little flattened in both specimens.

Species medium size. Calyx obconoidal, more rapidly spreading in the upper part than below, especially in the region of the secondary and tertiary radials; about one-half wider than high; plates convex, sculptured, more or less stellate; radial ridges angular in the superior part, and angles of the plates depressed.

Basals short, slightly constricted above; sutures beveled; columnar cavity broad and shallow. First radials rather wider than long, except the radial on the left of the azygous area, which is longer than wide, three hexagonal, two heptagonal Second primary radials about half as long as the first, hexagonal, and wider than high, except in the ray on the left of the azygous area, where the second radial is heptagonal and longer than wide. In this ray there is no third primary radial and the second occupies the position of the second and third primary radials. This feature may be abnormal, but as the first plate is larger than it is in either of the other rays the peculiarity must have commenced with the commencement of the growth of the specimen and is not due to any injury that it could have received. The fact that *Shumardocrinus* never had but two primary radials in any of its rays leads one to believe, that, in this species, one of the rays, in its

normal condition, may never have had more than two. While we have two specimens of this species this particular ray happens to be wholly preserved in only one of them. Third primary radials, in the four rays, a little larger than the second, three of them pentagonal, and the one on the right of the azygous area hexagonal, as shown in both of our specimens; all are axillary, and support on each upper sloping side a single secondary radial, which is axillary and supports upon each superior sloping side a single tertiary radial, except in the ray on the left of the azygous area, where there are two tertiary radials. This peculiarity in the ray having only two primary radials does not appear to be abnormal, and certainly is not the result of any mechanical injury. There are, therefore, twenty ambulacral openings to the vault.

In one of the regular interradial areas adjacent to the ray opposite the azygous area there are six plates, one of which connects with the plates of the vault, and in the other area there are seven plates, one of which connects with the plates of the vault. In the other two regular areas there are only five plates, neither of which reaches the plates of the vault, because the areas are cut off by the union of the tertiary radials. The azygous area contains nine plates. The first one is in line with the first primary radials and somewhat smaller; it is followed by two plates in the second range, five plates in the third range, and only one in the fourth range which is cut off from the vault by the union of the tertiary radials above it.

Vault very convex and having more capacity than the calyx. It is covered by large, polygonal, spiniform plates. The vault is injured at the summit in both of our specimens so the character of the proboscis cannot be determined. No ovarian pores discovered.

This species, in some respects, resembles a *Batocrinus*, but the hexagonal, second primary radials must place it in the genus *Actinocrinus*. The fact that the azygous area and the two interradial areas adjoining do not connect with the vault, while the other two interradial areas do, would seem to be of specific importance, without reference to the want of uniformity in the number of plates in the different areas. The ray on

the left of the azygous area, if normal, will distinguish this species from all others and as the ray on the right is the same in each specimen we think the one on the left is normal. The general form and surface ornamentation will distinguish this from all other species having twenty arm openings to the vault, though it resembles *A. fossatus* which has forty arm openings to the vault.

Found by R. A. Blair, in the Burlington Group, at Sedalia, Missouri, and now in the collection of S. A. Miller.

SAMPSONOCRINUS, n. gen.

[Ety. *The generic name is intended as a compliment to a distinguished naturalist, Mr. F. A. Sampson, of Sedalia, Mo.*]

Body more or less globose. Basals three, subequal, one pentagonal, two hexagonal. Primary radials either two or three in each radial series and differing in this respect in the different radial series in the same specimen. Secondary and tertiary radials present. Interradial plates connect with those of the vault, and, in three of the areas the first plate abuts upon the basals, by which arrangement eight plates unite with the basal disc. Vault elevated over the ambulacral canals, and depressed in the interradial spaces. Proboscis subcentral. Type *S. hemisphericus*.

We refer this peculiar genus to the family Actinocrinidæ.

SAMPSONOCRINUS HEMISPHERICUS, n. sp.

Plate III, Fig. 7, basal view; Fig. 8, summit view; Fig. 9, azygous side, the sutures between some of the plates being obscure; Fig. 10, lateral view.

General form of the calyx hemispherical, rather more than one half wider than high, broadly rounded below. Plates convex. Surface granular. Columnar facet very small. Arms directed horizontally.

One of the basal plates is pentagonal and two hexagonal, and they differ but little in size. When united they form a disc having three re-entering angles, in one of which an azygous plate is supported, and each of the others support a radial series. The pentagonal plate is truncated by a radial and the hexagonal plates are truncated by a radial and by an interradial. By

this arrangement the basal plates, when united, form a disc having eleven sides and abuts upon eight plates, a peculiarity we have never observed in any other fossil.

The first primary radials are longer than wide, very unequal in size, two pentagonal, two hexagonal, and one heptagonal. The radial series are so different that we will describe them separately. The first primary radial that truncates the pentagonal basal plate is the largest plate in the body, heptagonal, and has a width greater than its length. It is followed by a second primary radial, one-half smaller than the first, longer than wide and heptagonal. This is followed by a short, small, third primary radial that is heptagonal, axillary and supports upon each superior sloping side a small secondary radial, which gives to this ray two arm openings that enter the vault horizontally. In one of the series, supported in one of the re-entering angles of the basal disc, the first primary radial is very large and hexagonal. It is followed by a second primary radial, that is very large, wider than long, heptagonal, axillary, and supports on one of the superior sides a single, secondary radial, which is axillary and supports tertiary radials, and upon the other two secondary radials, the last of which is axillary and supports tertiary radials, which gives to this ray four arm openings to the vault, that are directed horizontally. In the other series supported in a re-entering angle of the basal disc, the first primary radial is much smaller than the one last described, longer than wide and pentagonal. It is followed by a second primary radial much larger than itself, wider than long, having eight sides, axillary and supporting, on the left lateral side a single secondary radial that is axillary and supports tertiary radials, and, on the superior side, a single secondary radial that is not axillary, and, on the right lateral side, a secondary radial that is axillary and supports tertiary radials, which arrangement gives to this ray five arms. It will be noticed here, that the two radial series supported in the re-entering angles of the basal dis[illegible] have no third primary radials. In the radial series, on the right of the azygous area, the first primary radial is large, longer than wide, hexagonal, and followed by a second primary radial, which is much smaller, hexagonal, and followed by a third primary radial, which is

still smaller, much wider than long, hexagonal, axillary, and bears upon each superior side a single secondary plate, which is short and axillary and bears tertiary radials, which gives to this ray four arm openings to the vault. In the radial series, on the left of the azygous area, the first primary radial is small, longer than wide, pentagonal, and followed by a second primary radial, nearly as large, longer than wide, hexagonal, and followed by a third primary radial, much wider than long, octagonal, axillary, and bearing on the superior sloping sides a single secondary radial, which is axillary and bears tertiary radials, which gives to this ray four arm openings to the vault. It will be observed that the three radial series that truncate the basal disc have, each, three primary radials, though the plates differ in relative form and size. There are, therefore, nineteen arm openings to the vault. The first arm plates are small, and the arms are directed horizontally. Beyond this, the arms are unknown.

The interradial areas differ, in form, and in the number of plates, and in position, as much as the radial series do, and, though they all connect with the vault and the plates grow less in size, until they unite with the plates of the vault, they will be separately described. In the area on the right of the azygous area, the first plate rests on the basal disc. It is large, longer than wide, hexagonal and is followed by two rather large plates in the second range, and five in the third range, which connect with the plates of the vault, but in this species there is no line separating the plates, in the interradial areas, from the vault, as they all graduate into each other. In the area on the left of the azygous area, the first plate rests on the basal disc. It is large, much longer than wide, heptagonal, and is followed by two plates, in the second range, that unite with three plates which belong to the vault. In the area on the right of the radial series that truncates the pentagonal plate belonging to the basal disc, the first interradial rests between the superior lateral sides of the first primary radials. It is moderately large, hexagonal, and is followed by two plates in the second range that unite with three plates belonging to the vault. In the area on the left of the radial series that truncates the pentagonal plate be-

longing to the basal disc, the first interradial rests between the superior lateral sides of the first primary radials. It is not as large as the corresponding plate last described, pentagonal and is followed by a single plate, in the second range, that unites with three plates belonging to the vault. This is the smallest of the interradial areas and has only two plates in it. In the azygous area as usual in the *Actinocrinidæ*, the first plate enters one of the re-entering angles of the basal disc, and is in line with the first primary radials. It is longer than wide, hexagonal and followed by two smaller plates, in the second range, three in the third, and four in the fourth, which unite with the plates of the vault in a zigzag line, without any definite mark of separation.

The vault is convex, having the radial areas highly and narrowly elevated with abruptly descending, wide interradial areas. It is covered with numerous, rather small, convex, polygonal plates. It had a small, subcentral proboscis, which is broken off in our specimen, at the summit of the vault

Found in the Chouteau limestone, at Sedalia, Missouri, by Mr. F. A. Sampson, and now in his collection.

AMPHORACRINUS SEDALIENSIS, n. sp.

Plate V, Fig. 34, summit view of a small specimen; Fig. 35, azygous side of a large specimen; Fig. 36, basal view of same; Fig. 37, summit view of same.

Species from medium to large size. Calyx semi-elliptical, or bowl-shaped, one-fourth wider than high, broadly rounded below. Interradial areas depressed between the arm bases where they unite with the plates of the vault. Plates convex, sculptured, more or less stellate. No radial ridges. Column round, medium size, and facet for attachment only slightly concave.

Basals short, and forming an hexagonal disc only about one-half wider than the diameter of the column. First radials a little wider than long, three hexagonal, two heptagonal. Second primary radials about two-thirds as large as the first, longer than wide, hexagonal. Third primary radials short, much smaller than the second, pentagonal, axillary and support on each upper sloping side a single secondary radial,

The secondary radials are directed nearly horizontally and stand out, their full length, from the interradial areas. There are ten arm openings to the vault.

There are three regular interradials in each area. The first one is as large as a second primary radial and reaches about as high, hexagonal, and supports two rather large plates that unite with the plates of the vault. There are nine plates in the azygous area. The first one is in line with the first primary radials and nearly as large. It is followed by two plates, equally as large, in the second range. There are four plates in the third range, though one of them touches one of the plates of the second range only at an angle, and on each side of the superior part there is a single plate. The last three plates unite with the plates of the vault.

The vault is highly elevated over the ambulacral canals and correspondingly depressed interradially. It is covered with numerous convex, polygonal plates and bears a large sub-central proboscis.

There is no described species very closely resembling this one, though we have no doubt that we have before us a true *Amphoracrinus*.

The large specimen illustrated was found by R. A. Blair, in the Chouteau limestone, at Sedalia, Missouri, and is now in the collection of S. A. Miller. The smaller specimen is from the same rocks and is in the collection of F. A. Sampson. The sculpturing is best preserved on the smaller specimen.

Family MELOCRINIDÆ.

MELOCRINUS SAMPSONI, n. sp.

Plate II, Fig. 27, basal view; Fig. 28, azygous side; Fig. 29, opposite view.

Species above medium size. Calyx obconoidal, as far as the secondary radials, which are directed horizontally, so as to give the summit a pentagonal outline; truncated by large column; diameter nearly twice as great as the height. Plates highly convex and more or less radiately sculptured.

The four basals form a short rim, which is slightly lobed by the depression of the suture lines, and almost covered below by the end of the column. First radials the largest plates

in the calyx, a little wider than high, three heptagonal, two hexagonal. Second primary radials about half as large as the first, wider than high, four hexagonal, one pentagonal. They differ somewhat in size. Third primary radials smaller than the second, the superior part directed nearly horizontally, three pentagonal, two hexagonal, axillary, and support on each upper sloping side a single secondary radial. The secondary radials are short and directed horizontally, and the articulating facets are quite concave, and each one is marked by a large ambulacral notch. There are only ten ambulacral openings to the vault.

There are five plates, in each regular interradial area. The first one is about as large as a second primary radial, it is followed by two smaller plates, in the second range, and these by two plates, in the third range, that separate the secondary radials and curve in upon the vault to unite with the plates of the vault. There are ten plates in the azygous area. The first one is in line with the first primary radials and of about the same size; it is followed by two plates in the second range, three in the third range, and four in the fourth range, that curve in upon the vault to unite with the summit plates.

The vault is unknown.

This species is so radically different from all others that have been described, that no comparison with any of them is necessary.

Found by Mr. F. A. Sampson, the well known and prominent naturalist, in the Chouteau limestone, at Sedalia, Missouri and now in his collection. The specific name is in honor of the collector.

Family DOLATOCRINIDÆ.

DOLATOCRINUS NODOSUS, n. sp.

Plate III, Fig. 1, basal view; Fig. 2, azygous side view; Fig. 3, summit view.

Species above medium size. Calyx hemispherical, broadly truncated below. No radial ridges. Each plate bears a prominent conical central node, from the base of which there are numerous, more or less interrupted radiating lines, and toward the upper part, irregular, low, scattering nodes. Column round and having a large cinque foil columnar canal.

Basal plates almost covered by the column. First primary radials wider than long, the two on the azygous side being somewhat larger than the others. Second primary radials about one half wider than long, quadrangular. Third primary radials expand slightly to the superior lateral angles longer than the second, pentagonal, axillary, and in the ray on the right of the azygous area bears a single, secondary radial upon each superior, sloping side, which is axillary, and bears upon each superior sloping side two tertiary radials, which gives to this ray four arms. In each of the other four rays, the third primary radial bears upon one upper sloping side three secondary radials, and upon the other, one secondary radial, which is axillary, and supports upon each upper sloping side, two tertiary radials. This arrangement gives to each of these rays three arms. There are, therefore, sixteen arms and sixteen ambulacral openings to the vault in this species.

The azygous area is like the others, except a little larger. The first interradials are the largest plates in the calyx, have nine sides, and are broadly truncated above for the second interradials. The second interradials are about half as large as the first, and are followed by a single plate, which is about half as large as the second, and unites with two large, elongated plates belonging to the vault.

The vault is very slightly elevated over the radial areas, and about equally as much depressed in the interradial areas. It is substantially covered by three circles of plates, the surface of which is covered by granules, and a few of the plates over the radial areas bear a small central node, as shown in the illustration. The subcentral azygous opening is slightly elevated and surrounded by four plates, two of which form part of the first circle of plates and, if counted with the first circle, there are seven plates in the first circle, and without them there are only five; but the circle is not complete without counting one of them. In the second circle there are seven plates. In the third circle there are fifteen plates, two in each depressed interradial area that unite with the plates of the calyx and one over each radial area. These are all the plates covering the vault except those over the radial areas at the base of the arms. There are no ovarian openings, at least, in a beautifully preserved specimen none can be discovered.

This species bears more resemblance to *Dolatocrinus bellulus* than to any other, but is readily distinguished by having only sixteen instead of seventeen arms, and by having no ovarian openings. There is also some difference in the convexity and structure of the vault and in the surface ornamentation.

Found in the Hamilton Group, near Charlestown, Indiana, and now in the collection of Mr. J. F. Hammell, of Madison, Indiana.

DOLATOCRINUS SACCULUS, n. sp.

Plate III, Fig. 11, basal view; Fig. 12, side view.

Species medium or below medium size. Calyx subhemispherical, broadly truncated at the base and subcylindrical above. Radial ridges consisting of small, rounded elevations, which are interrupted by central nodes on the plates. Surface ornamented with radiating ridges from the central part of the plates that do not unite with the radial ridges or coalesce with the central nodes. The radiating ridges are toward the margin of the plates, and the second interradials have no central nodes. Column round, medium size, and having a large cinque foil canal.

Basal plates hidden by the column and a rounded flanging rim that surrounds it, on the basals and at the commencement of the first primary radials. First primary radials a little wider than long, and subequal in size. Second primary radials rather less than twice as wide as long, quadrangular, sides nearly parallel. Third primary radials very little larger than the second, from one-half wider to twice as wide as long, pentagonal, axillary, and bear upon each superior sloping side a single secondary radial. The secondary radials bear upon each superior sloping side a single tertiary radial, which gives to this species twenty ambulacral openings to the vault.

The first interradials are rather large and have nine sides. There is only a single plate in the second range and it extends to the top of the calyx and connects with the plates of vault. The azygous area is not materially different from the other areas.

The vault is moderately convex and bears rather sharp radial ridges. The sutures cannot be distinguished in our specimen. There are twenty ovarian apertures, one on each side of each

pair of arms. They are elongated and are close to the ambulacral canals, and not through the vault itself as in some species.

This species, when compared with *D. corporosus*, will be found to have only a single tertiary radial, while in that species there are four, and only two interradials, while in that species there are from three to six plates, and the azygous area is altogether different. There are also some minor differences in surface ornamentation and otherwise. There is no necessity for comparing it with any other known species.

Found by Geo. K. Greene, in the Hamilton Group, near Charlestown, Indiana, and now in the collection of Wm. F. E. Gurley.

DOLATOCRINUS SALEBROSUS, n. sp.

Plate III, Fig. 13, basal view; Fig. 14, side view; Fig. 15, summit view.

Species medium or below medium size. Calyx subhemispherical, concave below and slightly constricted below the arms. Radial ridges consisting of small, rounded elevations which are interrupted by central nodes on the plates. Surface ornamented with radiating ridges from the nodes and central part of the plates. The second interradials have a transverse central ridge with longitudinal ridges below it. Column round medium size, and nearly filling the funnel-shaped cavity formed by the basal plates.

Basal plates form a cup that is inserted into the cavity of the calyx and is nearly filled by the end of the column. The mouth of the cup is about one-fourth wider than the diameter of the column. First primary radials about as long as wide and curve, at the lower end, into the basal concavity to unite with the basal plates, and upward at the superior end, so that the calyx will rest upon the middle part of these plates. Second primary radials from one-fourth to one-half wider than high, quadrangular, and slightly expanding upward. Third primary radials a little larger than the second, about one-half wider than high, three hexagonal, two pentagonal, axillary, and, in two of the rays, bear upon each upper sloping side a single secondary radial which is axillary and bears upon each superior side two tertiary radials, which gives to each of these rays four arms. In each of two other rays, the third primary

radial bears upon one superior sloping side two secondary radials and, upon the other, a single secondary radial, which is axillary and supports, on each superior sloping side, two tertiary radials, which arrangement gives to each of these two rays three arms. The other ray, in its normal condition, may be like the last two, and if so, the species will have seventeen arms, but in the specimen illustrated, it is different and is peculiarly constructed, as follows. Upon one side of the third primary radial there is a single secondary radial, which is axillary and bears upon each superior side a single tertiary radial, and, upon the other side of the third primary radial, an interradial is supported, without the intervention of a secondary radial, and, therefore, there are only two arms to this ray, which gives us only sixteen arms in the specimen illustrated, and, until it can be shown, that this structure is abnormal, the species must be regarded as possessing only sixteen arms.

The first interradials are of unequal size, one of them is heptagonal and each of the others has nine sides. The heptagonal plate is followed by two plates, in the second range, one of which rests, in part, on one of the superior sides of a third primary radial and takes the position of a secondary radial in the two-armed ray. These two plates in the second range connect with two plates belonging to the vault. In the other four areas, one plate, in the second range, is followed by one in the third range that unites with two plates belonging to the vault.

The vault is moderately convex over the ambulacral canals and correspondingly depressed in the interradial areas. It is covered by a few rather large polygonal plates that bear pustules, and each one over the junction of the ambulacral canals bears a central node. The azygous orifice is central. No ovarian pores can be distinguished.

We regard the interradial area having the first plate heptagonal as the azygous area, and, if the two-armed ray is abnormal and the species has seventeen arms, then it will resemble *D. aureolus*, from which it will be readily distinguished, by the interradial areas: for in that species, there are three plates, in the third range, that unite with the plates of the vault, in

the regular areas, and four or five in the azygous area. Besides, the ornamentation is different in the two species, and the proboscis in that species is large and subcentral and the arrangement of the plates on the vault is quite different in the two species. But if the two-armed ray is normal then this is a sixteen armed species so different from all other sixteen armed species that have been described, that no comparison with any of them is necessary.

Found by Geo. K. Greene, in the Hamilton Group, near Charlestown, Indiana, and now in the collection of Wm. F. E. Gurley.

Family POTERIOCRINIDÆ.

POTERIOCRINUS BLAIRI, n. sp.

Plate IV, Fig. 1, azygous view, the arms on the right a little compressed; Fig. 2, view showing the ray opposite the azygous area on the left, one of the arms is spread out of place.

Species medium size, robust, and having wide arms that fit closely together as in *Zeacrinus*. Calyx obconoidal, nearly twice as wide as high, truncated below for a rather large column; sutures distinct; surface smooth.

Basals very short, three or four times as wide as high. Subradials wider than high, three haxagonal, and two heptagonal; those adjoining the azygous area are heptagonal.

First radials of unequal size, but about twice as wide as high; truncated the entire width above and separated from the first brachials or arm plates by a slightly gaping suture. The second radials or brachials, as they are usually called, are of unequal size and not uniform in shape. In four of the rays these plates are wider than high, pentagonal and support upon each upper sloping side the secondary radials or free arms. The secondary radials are short, wide, quadrangular and abut against each other. In one of the series, the fifth plate is pentagonal, axillary and supports upon each upper sloping side the tertiary radials; in the other series, preserved in our specimen, the sixth plate is axillary, pentagonal and supports on each upper sloping side the tertiary radials. No further bifurcation is shown, though ten tertiary radials are

preserved. The tertiary radials are short, wide, quadrangular, and abut against each other, in the same manner that the secondary radials do. This arrangement gives to each of these four rays four arms. In the ray opposite the azygous area, the second primary radial is the largest plate in the body and nearly square. It is followed by a short, quadrangular plate, and then follows a short pentagonal plate, that is axillary and supports upon each upper sloping side a long series of short, wide, quadrangular, secondary radials, which gives to this ray two arms. There are, therefore, eighteen compact arms in this species.

The azygous area is of moderate size and the plates are arranged as is usual in this genus. The first one is pentagonal and rests between the sloping sides of two subradials and below the under sloping side of the first radial, on the right. The second plate is long, hexagonal, truncates a subradial and reaches as high as the top of the second radial on the left. The fourth plate is much smaller than the third, truncates the second and extends a little beyond the third. The fifth plate truncates the third and is not fully exposed in our specimen.

This species is readily distinguished by its general form, and, so far as known, has no nearly related species, in the group of rocks, in which it occurs.

Found by R. A. Blair, in the Burlington Group, at Sedalia, Missouri, and now in the collection of S. A. Miller. The specific name is in honor of the collector.

POTERIOCRINUS ALTONENSIS n. sp.

Plate IV, Fig. 3, azygous area on the right, calyx arms and part of the column, compressed; Fig. 4, opposite view of same specimen.

Species quite small, constricted above the calyx in the middle of the second radials or brachials. Calyx short, hemispherical or bowl-shaped, nearly twice as wide as high; plates convex; sutures distinct; surface granular. Column quite small and round, the alternate plates slightly projecting.

Basals depressed and extending a little beyond the column, so as to be seen from a basal view. Subradials rather wider than long and forming, with the basals, a low cup. First radials wider than long, pentagonal, truncated the entire width above and separated from the second radials or brachials by a

gaping suture. A single, elongated, brachial or second radial, rounded and contracted in the middle, and axilliary, supports upon its superior sloping sides, in each radial series, the free arms. The arms are long, slender, round and composed of rather long plates which are slightly constricted in the middle part. The first plates are longer than the succeeding ones. The arms do not bifurcate and there are, therefore, only ten arms in this species. Pinnules distant.

Azygous plates are as usual in this genus; the first one is pentagonal, about half as large as a subradial, rests upon the upper sloping sides of two subradials and between the first radial, on the right, and the second azygous plate, on the left, and is truncated, at the top, for the third azygous plate; the second plate is pentagonal, about as large as the first, rests upon the truncated upper end of a subradial, and between a first radial, on the left, and the first and third azygous plates, on the right, and is truncated at the upper end, for the fourth plate. The fourth plate extends beyond the third.

This species is distinguished by its small size, hemispherical calyx, long, constricted brachials and ten arms. When compared with *P. rowleyi* it will be noticed, that species has two brachials, in some of the rays, and all the arms bifurcate toward the top. It will not be mistaken, for any other species, by any one capable of making a comparison.

Found by the late Hon Wm. McAdams, who was a prominent naturalist, in the St. Louis Group, at Alton, Illinois, and now inthe collection of S. A. Miller.

POTERIOCRINUS BROADHEADI, n. sp.

Plate IV, Fig. 7, azygous side view; Fig. 8, lateral view.

We have examined six specimens belonging to this species, one a third larger than the specimen illustrated, three others as much smaller, and each one is longer and larger upon the azygous side than upon the opposite side, showing the unsymmetrical form of the calyx is normal. Calyx irregularly obconoidal above the broad truncated base, by reason of the longitudinal convexity of the plates and the depressed sutures, or it might be called somewhat obpyramidal. The azygous side is longer than the other, the two rays opposite the azygous

area are the shorter and of equal length, and, from these, there is a gradual lengthening to the top of the third azygous plate. All the plates are longitudinally convex and the sutures are depressed, especially at the angles, and a pore penetrates the calyx at every angle, and, on the longer sides, a pore penetrates the calyx between the angles. The greatest length of the calyx does not equal the diameter. Plates thick. Column unknown.

Basals small, wider than long, and project below the end of the column. Superior angles rather acute. Subradials the largest plates in the calyx and about as long as wide, though somewhat unequal in size, three hexagonal, two heptagonal. First radials about twice as wide as long, though of unequal length, and slightly concave the entire width above for the reception of the second radials, none of which are preserved in our specimens.

The first azygous plate is about as large as a first radial, nearly equal sided, pentagonal, rests between the superior sloping sides of two subradials, separates the first radial, on the right, from the second azygous plate, on the left, and is truncated above by the third azygous plate. The second azygous plate is nearly as large as the first, truncates a subradial, separates the first radial, on the left, from the first and third azygous plates, and thins toward the upper edge, indicating that it united with small plates belonging to a proboscis. The third azygous plate rests upon the first and in its lower part separates part of the first radial plate, on the right, from the second azygous plate and thins toward the upper edge, indicating that it united with small plates belonging to the proboscis.

This is a peculiar species and on account of its azygous area and the pores that penetrate the vault, may yet be made the type of a new genus. At least it will not be confounded with any species that has been heretofore described in this genus.

Found by R. A. Blair, in the Chouteau limestone, near Sedalia, Missouri, and now in the collection of S. A. Miller. The specific name is in honor of Prof. G. C. Broadhead.

POTERIOCRINUS SAMPSONI, n. sp.

Plate IV, Fig. 9, azygous side view; Fig. 10, opposite view of same, some of the matrix is attached to the top of the first radials.

Species medium or below medium size, as indicated by two specimens, one of which is smaller than the one illustrated. Calyx like the frustum of a cone, being broadly truncated below, slowly expanding above and having a diameter about one-fourth greater than the height. Surface smooth, possibly, in better preserved specimens, granular. Plates thick and sutures close. Column large, at the superior end, as it entirely covers the truncated end of the calyx.

Basals moderate size, about a third or a half wider than high. Superior angles distinct though not acute. Subradials the largest plates in the calyx, wider than long, though unequal in size, three hexagonal, two heptagonal. First radials about twice as wide as long, though slightly unequal in size, and truncated the entire width above, for the reception of the second radials, none of which are preserved, in our specimens. The first azygous plate is smaller than a first radial, nearly equal sided, pentagonal, rests between the superior sloping sides of two subradials and separates the first radial, on the right, from the second azygous plate. The second azygous plate is much smaller than the first, truncates a subradial and separates the first one from the first radial, on the left. The third azygous plate is smaller than the second, as shown by the specimen, which is not illustrated, and beyond it, the plates are not preserved.

While this species is not distinguished by any very remarkable peculiarities, it is so different from any that have been described from rocks of the same geological age, that no comparison is necessary.

Found by R. A. Blair, in the Chouteau limestone, at Sedalia, Missouri, and now in the collection of S. A. Miller. The specific name is in honor of F. A. Sampson, a distinguished naturalist of Sedalia.

ZEACRINUS BLAIRI, n. sp.

Plate IV. Fig. 5, azygous side; Fig. 6, opposite side of same specimen, showing part of the proboscis.

Species below medium size. Calyx low, basin-shaped, two and a half times as wide as high, depressed at the base, plates convex, sutures distinct, surface granular. Column small and round.

Basals form a disc one-half larger than the diameter of the column, and, in plain view, as seen from below. Subradials wider than high, and forming, with the basals, a low cup. First radials wider than long, pentagonal, truncated the entire width above, and separated from the brachials by a gaping suture. A single brachial, about as long as wide, rounded and contracted, in the middle, and axillary, supports upon its upper sloping sides, in each radial series, the free arms. The proximal arm, on the left of the azygous area, bifurcates on the sixth plate, and the proximal side again on the ninth plate, and the distal side bifurcates on the fourth plate, and the distal branch on the eighth plate, which gives to this ray six arms. The ray opposite the azygous area bifurcates, on one branch, on the fourth plate, and, on the other, on the seventh plate, which gives to it four arms. One of the lateral rays bifurcates, on each branch, on the sixth plate, which gives to it four arms. The other two rays are broken off below the first bifurcation, in our specimens, but we presume the lateral rays are alike, and the ray on the right of the azygous area the same as the one on the left, and if so, the species has twenty four arms. The arms are short, round and composed of short plates. Pinnules small.

The azygous area is wide, ovate and exposes ten plates arranged alternately, as usual, in this genus. The first one is about half as large as a subradial, rests upon one sloping side of a subradial and abuts another, separates the first radial, on the right, from the second azygous plate and is truncated by the third plate. The second one is about the size of the first, truncates a subradial, separates the first radial, on the left, and the lower part of the brachial, from the first and third plates and is truncated above by the fourth and fifth plates. The fourth, fifth and sixth plates are in one range crossing

the exposed area. The top of the proboscis is broken off in the specimen illustrated, below the top of the arms, where it is round and covered by smooth, polygonal plates.

This species is at once distinguished, by its general form and number of arms, from all others. In *Zeacrinus pocillum*, from the same rocks, there are two brachials in each of four rays, and, in the other ray, the first brachial is truncated on top and followed by five single plates, before it bifurcates; and *Zeacrinus commaticus*, from the same rocks, with its forty-six arms, is equally as far removed from this species. We know of no species with which it is necessary to compare it.

Found in the Keokuk Group, at Boonville, Missouri, and now in the collection of S. A. Miller. The specific name is in honor of R. A. Blair, the distinguished naturalist and collector of Sedalia, Missouri.

Family CYATHOCRINIDÆ.

CYATHOCRINUS BLAIRI n. sp.

Plate IV, Fig. 11, basal view of a large specimen, azygous side up; Fig. 12, azygous side of same showing the large subradial; Fig. 13, basal view of a small specimen; Fig. 14, azygous side of the same; Fig. 15, opposite side of same.

We have three specimens of this species, though one of them is so badly crushed that it is of no service in the description. The species is rather below medium size. The calyx of the larger specimen is bowl-shaped, a little less than twice as wide as high and broadly rounded below, while the smaller specimen is more elongated and pointed below. It is possible, that the larger specimen is compressed on the under side so as to throw it a little out of its normal shape. The sutures are beveled; surface granular; column small and round.

Basals small and form a low cup, with a concave depression for the attachment of the small column, and are separated from the subradials by a beveled suture. Subradials large and gently curve from the basal cup outward and upward. The one on the azygous side is remarkably large and extends nearly as

high as the first radials. First radials wider than high, sides parallel, each arcuate the entire width above for the attachment of the second plate, and having the facet directed upward or slightly inclined inward. The first azygous plate is short and extends but slightly below the level of the first radials.

This species will be distinguished by its general form, remarkably large subradial which is truncated by a short azygous plate, and by the wide arcuate facets directed upward and inward, for the attachment of the second radials. Possibly its arms, when known, will be used to distinguish it from the genus *Cyathocrinus*.

Found by R. A. Blair, in the Chouteau limestone at Sedalia, Missouri, and now in the collection of S. A. Miller. The specific name is in honor of the laborious and intelligent collector.

CYATHOCRINUS CHOUTEAUENSIS, n. sp.

Plate IV, Fig. 16, showing calyx and part of the arms, the azygous plate is on the right and the second and third radials in the adjoining ray are out of place, the calyx is also compressed so as to appear wider than it is.

Species medium size. Calyx obconoidal, about as high as wide, sutures close, surface granular.

Basals form a low conical cup, truncated for a small column. Superior angles obtuse. Subradials rather longer than wide, except the one truncated by the azygous plate which is wider than long, four hexagonal and one heptagonal. The heptagonal plate is the larger one. First radials about as long as wide, slightly curved over towards the vault on each side of the arm facets, and longitudinally convex and protuberant at the arm facets. Arm facets circular, occupying about half the width of the plates, and notched for the ambulacral canal. Azygous plate broadly truncates a subradial and extends above the top of the first radials.

There are only five arms. The arms are small, long and composed of long, round joints or plates. The first plate is not quite as long as wide but above this the plates are from two to four times as long as wide.

There is no described species, from rocks of the same age, with which this one can be confounded.

Found by the distinguished collector and naturalist F. A. Sampson, in the Choutean limestone at Sedalia, Missouri, and now in the collection of S. A. Miller, to whom he kindly presented it.

CYATHOCRINUS MACADAMSI, n. sp.

Plate IV. Fig. 31, azygous side on the right; Fig. 32, lateral view.

Species medium size, constricted above the calyx. Calyx short, hemispherical, twice as wide as high; plates convex; sutures distinct; surface finely granular. Column small.

Basals form a flat pentagonal disc about twice as wide as the diameter of the column. Subradials slightly wider than high and forming with the basals a low cup. First radials about one-half wider than long, pentagonal, truncated the entire width above, and separated from the second radials or brachials by a wide gaping suture. There are two brachials in each ray, the first one is quadrangular and about twice as wide as long, the second is somewhat smaller than the first, pentagonal, axillary and supports upon each upper sloping side a single arm. The body is broadly constricted in the region of the brachials. There are only ten arms and when closed they are compact, as the sides are straight and flattened. The arms are composed of wedge-shaped plates, the first ones being longer than the succeeding ones. In the three specimens examined there is some difference in the length of the arm plates and the longer ones appear to be slightly constricted, but the difference will not distinguish either specifically from the one illustrated. The first azygous plate truncates a subradial and extends a little above the top of the first radials.

The form of the calyx and the azygous plate agree with *Cyathocrinus*, but the brachials and arms remind one of *Poteriocrinus* and *Zeacrinus*. There is no described species for which this one can be mistaken.

Found by the late Hon. Wm. McAdams, in the St. Louis Group, at Alton, Illinois, and now in the collection of S. A. Miller. The specific name is in honor of the collector, who was well known as a naturalist of ability and close observation for many years.

CYATHOCRINUS BRITTSI, n. sp.

Plate IV, Fig. 35, basal view; Fig. 36, azygous side view of the calyx.

Species medium size. Calyx rather more than twice as wide as high, and somewhat obpyramidal in shape, in the superior part, though round over the subradial region. Sutures distinct, surface granular. Column large and round.

Basals form a pentagonal disc, one-third wider than the diameter of the column, which has a concave depression, though shallow, for the attachment of the column. Subradials slightly wider than high, the one on the azygous side being much larger than either of the others, though extending but little higher. First radials a little wider than high, longitudinally convex, most convex in the superior part, which gives the calyx, when seen from above, a subpentagonal outline. The upper part of these plates, too, is very thick, and the facets for the articulation of the second plates are correspondingly deep, and scarred very slightly, for the ambulacral canal. The facets are about three-fourths of the width of the plates, and have a slight transverse depression that indicates a gaping suture. The first azygous plate broadly truncates a subradial at about the middle of the first radials.

This species will be distinguished, by its general form, from all others, so that no comparison with any of them is necessary for its identification.

Found by R. A. Blair, in the Burlington Group, at Sedalia, Missouri, and now in the collection of S. A. Miller. The specific name is in honor of Dr. J. H. Britts, one of the leading naturalists of Missouri.

FAMILY PLATYCRINIDÆ.

PLATYCRINUS TUGURIUM, n. sp.

Plate IV, Fig. 17, basal view; Fig. 18, azygous side view; Fig. 19, summit view.

This species is above medium size, and belongs rather to the discoid than to the bowl-shaped forms, and receives its specific name from a fanciful resemblance to a hut. Calyx shallow, pentagonal, two and a half times as wide as high. Plates thick, sculptured. Sutures beveled. The surface is ornamented

with angular ridges and furrows as follows: An angular ridge extends from each angle of the basal disc to the columnar depression, and two or three ridges parallel with each side of the disc, are arranged between them; and, on each first radial, an angular ridge extends from each lower lateral angle, from one-half to two-thirds the length of the plate, to a constriction, or subcircular furrow, and these ridges are connected by three ridges parallel with the lower side, and there are three ridges between the subcircular furrow and each perpendicular suture.

Basals form a pentagonal disc, not higher than the thickness of the plates, with a concave depression in the central part, where the column attached; and sculptured as above described, though the sculpturing becomes less defined as it approaches the concave depression. First radials project, in the lower part, at an angle of about forty degrees; but, the superior part, beyond the constriction, is directed horizontally, and the facet, for the second plate is transverse, or nearly perpendicular, with a notch for the ambulacral canal. Surface ornamentation as above described. The angles for the reception of the interradials are more acute than is usual in this genus. There is only a single regular interradial, in each area, and it forms part of the vault.

Vault elevated and convex toward the central part, so as to have a capacity equal to or greater than the calyx. A single large spinous plate occupies the central part; it is surrounded with eight plates, six of which bear spines and the other two abut upon the azygous orifice. Each plate over the junction of the ambulacral canals bears a spine, the other plates are convex but not nodose. The azygous area is comparatively large, the first plate is as large as a regular interradial and stands nearly upright, and above on either side of it there are two small plates, and between and above these nine plates surround a large azygous orifice.

This species is readily distinguished by its general form and surface ornamentation from all heretofore described.

Found in the Burlington Group, at Sedalia, Missouri, by R. A. Blair, and now in the collection of S. A. Miller.

PLATYCRINUS FORMOSUS, n. sp.

Plate IV, Fig. 20, basal view; Fig. 21, azygous side view preserving the first azygous plate.

This species is about medium size and belongs to the discoid forms. Calyx shallow, pentagonal, four times as wide as high. Plates thick, sculptured. Sutures canaliculate. The surface is ornamented with a rounded ridge upon each side of the canaliculated sutures which bears more or less conspicuous rounded nodes. Column round.

Basals form a concave pentagonal disc, bordered by an angular nodose rim, that adjoins the canaliculated suture. The concavity is equal to the thickness of the plates and commences at the angular ridge adjoining the suture. The plates are serrated for the attachment of the column. The first radials project, at first, horizontally, and then curve upward, having a constriction in the middle part, beyound which they are directed horizontally, and the facet, for the second plate, is transverse or nearly perpendicular. Each articulating facet forms almost a circle, having a diameter more than one third the diameter of the plate, and being only slightly notched for the ambulacral canal.

The angles for the reception of the regular interradials are very obtuse, and the angle for the reception of the first azygous plate is moderately acute. The first azygous plate is pentagonal, stands upright and indicates a large area on account of its width, but it is shorter than the same plate in *P. tuguriun*, and the probability is that the vault is less convex.

The calyx of this species has some resemblance in form to *P. truncatus*, but in that species, the base is flat and the surface is not ornamented, while in this species, the basal disc is quite concave and the column is inserted into the concavity and the surface is ornamented with ridges and nodes. Other differences in form, occur in the parts preserved. It cannot be mistaken for any other described species by any one capable of distinguishing specific characters.

Found by R. A. Blair, in the Burlington Group, at Sedalia, Missouri, and now in the collection of S. A. Miller.

PLATYCRINUS MISSOURIENSIS, n. sp.

Plate IV., Fig. 22, longer side view, showing the place for the attachment of the column; Fig. 23, shorter side view.

Species medium size, and the specimen upon which it is founded has longer first radials upon one side than upon the other, which forms an unsymmetrical calyx that may represent either the normal or an abnormal growth. It is also slightly compressed. Calyx somewhat bowl-shaped, broadly truncated below, outer face of the first radials flattened and sutures beveled, so that a transverse section will have a subpentagonal outline. Plates thick. Surface granular. Column round at the point of attachment, rather large and surrounded by a small projecting rim on the basals. Columnar canal large.

Basals form a pentagonal disc with a very shallow cup and have a projecting angular rim around the end of the column. The beveled and straight sutures between the basals and first radials give the basals a marked pentagonal outline. The first radials are a little larger upon one side of our specimen than upon the other, the longer ones expand most, so that each is only slightly wider than high. Each plate is flattened below the articulating facet for the second radial. Articulating facets very large, occupying from one-half to two-thirds the width of each plate and having a serrated outer edge, within which there is a straight tranverse ligamental furrow. Wide notch for the ambulacral canal.

This species is distinguished by its bowl shape and pentagonal outline, and remarkable articulating facets for the second radials.

Collected by R. S. Blair in the Chouteau limestone near Sedalia, Missouri, and presented by him to S. A. Miller.

PLATYCRINUS PETTISENSIS, n. sp.

Plate IV, Fig. 24, basal view; Fig. 25, side view of same specimen.

Species medium sized. Calyx bowl-shaped, truncated for the attachment of the column and projecting at the arm bases, so as to give it a pentagonal outline above. Surface smooth in the four specimens examined, and sutures slightly beveled. Column medium size.

Basals form a cup about twice as wide as high, pentagonal at the top, and truncated for the column. First radials wider

than high, gradually expanding, convex longitudinally and projecting at the articulating scales. Articulating facets rather large, directed upward, at an angle of about sixty degrees, form more than a semicircle, occupy about half the width of a plate and are notched in the central part for the ambulacral canal.

This species is founded upon four specimens the larger one of which is illustrated. It resembles *P. amosus* more than any other described species, but will be distinguished from it, by the higher cup formed by the basal plates, larger truncation for the column, and more prominent and larger articulating facets for the second radial. We have examined fifteen specimens of *P. amosus*, and the above differences are constant, and the species need not be confounded even on a superficial examination.

Collected by R. A. Blair, in the Chouteau limestone, in Pettis county, Missouri, near Sedalia, and by him presented to S. A. Miller.

PLATYCRINUS CLINATUS, n. sp.

Plate IV, Fig. 26, shorter side of a large specimen; Fig. 27, longer side of same; Fig. 28, longer side of another specimen, showing an interradial on the azygous side; Fig. 29, shorter side of same; Fig 30, longer side of a smaller specimen.

We have examined ten specimens belonging to this species, ranging in size between the largest and smallest specimens illustrated, and we believe the specimen illustrated by figure 4, plate I, Bulletin No. 1, Geo. Sur. Mo., belongs to this species, though it is not at hand for re-examination. All of the specimens are larger on one side than on the other, and the first radials are longer on one side than on the other, proving that this is the normal condition of the species. The larger side is the azygous side and opposite to the small basal. The basal plates are generally anchylosed, but in the specimens illustrated we have been able to see the sutures.

Species below medium size. Calyx with a large truncated base, above which it is abruptly constricted and then gradually

expands to the top of the basals, and, from there, expands more rapidly to the facets for the second radials, which gives it a pentagonal outline on top. Sutures between the radials and between the basals and radials beveled. Surface granular. Plates thick. Column round and large.

Basals form a short subcylindrical cup, with an expanded base. First radials of unequal size, differing as much in width as in length, and subquadrate in outline; they are longitudinally convex in the central part, projecting most at the articulating facets for the second radials, and depressed at the longitudinal sutures. Articulating facets large, occupying about two-thirds the width of each plate, and sloping downward so as to be directed at an angle of sixty degrees, from a perpendicular line. The azygous interradial is large and stands nearly upright. The angles for the reception of the regular interradials are very obtuse.

This species will be readily distinguished, by its general form and thick plates, from all others. It bears most resemblance to *Platycrinus allophylus*.

Found by R. A. Blair, in the Chouteau limestone, at Sedalia, Missouri, and now in the collection of S. A. Miller.

PLATYCRINUS SULCIFERUS, n. sp.

Plate IV, Fig. 33, basal view; Fig. 34, side view.

Species above medium size and belongs to the discoid forms. Calyx shallow, pentagonal, two and a half times as wide as high. Plates thick, furrowed. Sutures broadly beveled.

Basal disc large, pentagonal, concave in the central part and having a furrow just within the pentagonal border. First radials wider than high, project at an angle of about forty-five degrees, sharply constricted below the facets for the second radials. The facets are semi-elliptical, directed horizontally, and broadly notched for the ambulacral canal. There is a furrow just within the beveled edge adjoining the basal disc, and one on each side of each plate adjoining the beveled suture. The angles for the reception of the regular interradials are obtuse. The vault and arms are unknown.

This species is distinguished from other discoid species having beveled sutures, by the furrow within the border of each plate, without other ornamentation by the sharp angular con-

striction below the articulating facet, and by the semi-elliptical facet. These surface characters readily distinguish it from other species.

Found by R. A. Blair, in the Burlington Group, at Sedalia, Missouri, and now in the collection of S. A. Miller.

PLATYCRINUS CASULA, n. sp.

Plate IV, Fig. 37, basal view; Fig. 38, azygous side on the right; Fig. 39, view opposite the azygous side; Fig. 40, summit view.

Species medium size and belongs to the bowl-shaped forms. Calyx bowl shaped, pentagonal, rather more than one and a half times as wide as high. Plates thick. Sutures broadly beveled. Surface without ornamentation. Column round at the calyx.

Basal disc pentagonal, nearly three times as wide as the diameter of the column and having a height about equal to the thickness of a plate. It is concave below for the column attachment, and bordered by an angular pentagon from which it is beveled to the suture above. First radials a little wider than high, slowly expand to form the cup and become convex toward the facets, for the second radials. The facets are semi-elliptical, directed at an angle of forty-five degrees, and occupy about half the width of the plates. The second radials are very short and axillary. The ambulacral notch is small in both the first and second radials. The angles for the reception of the interradials, which are in fact plates of the vault, are quite obtuse.

The vault is only slightly convex and is covered with a few rather large convex plates. Five large plates occupy the central part and these are surrounded by a single row of plates consisting of the interradials and those covering the ambulacral canals and those forming the proboscis on the azygous side. The proboscis is large and consists of numerous small plates, and the first azygous interradial, which is large, stands upright and forms part of it.

The species is distinguished by its pentagonal, bowl-shape, absence of ornamentation and peculiar vault and proboscis.

Found by R. A. Blair in the Burlington Group, at Sedalia, Missouri, and now in the collection of S. A. Miller.

PLATYCRINUS SEMIFUSUS, n. sp.

Plate IV, Fig. 41, side view; Fig. 42, basal view.

This species is founded upon two casts, but the specimens are in a fine state of preservation, and the ornamentation, we presume, indicates the ornamentation of the test. The species is above medium size. The calyx is pointed below, subpentagonal from the basals upward and constricted below and at the second radials, so as to destroy the subpentagonal outline. The heigth is a little more than the diameter and if the test were preserved the heigth would still be more than the diameter. The shape is half fusiform. The surface is ornamented with rounded ridges that radiate downward from the second radials to the base of the first radials and then contract to the pointed base below, and these ridges bear very fine longitudinal lines; or we might say the specimens are ornamented with longitudinal, low, fusiform ridges, that are longitudinally marked with very fine lines.

Basals form a cup, pentagonal above and pointed below, and having a diameter equal to about two and a half times the height. The first radials have a length greater than the width and have nearly parallel sides. The facets for the articulation of the second radials are very small. The vault is unknown.

The general form will distinguish this species from all others, beside, the surface ornamentation is quite peculiar.

Found by R. A. Blair in the chert belonging to the Burlington Group, at Sedalia, Missouri, and now in the collection of S. A. Miller.

PLATYCRINUS MODESTUS, n. sp.

Plate IV, Fig. 43, side view; Fig. 44, basal view; Fig. 45, Summit view, of the same specimen.

We have several specimens of this species, but they are all casts. The species is below medium size. The calyx is bowl-shaped, pentagonal, and about one third wider than high. It is constricted below the arms. There are no indications of any ornamentation.

Basals form a nearly flat, pentagonal disc. The first radials have a width a little greater than the length and they expand moderately upward. The superior angles are strongly truncated

for the reception of the interradials. The facets for the articulation of the second radials are not preserved, but the ambulacral canals make a delicate notch in the middle of each first radial.

The vault is elevated and convex, the first interradials are large and stand nearly upright, but curve the superior end slightly over on the vault. The ambulacral canals are remarkably deep and form elevated rounded ridges on the summit of the vault; in other words, they cut the first radials and form the highest part of the vault. The vault is covered with polygonal plates, the central one being about as large as an interradial. The proboscis is sub-central.

While there are some pentagonal, bowl-shaped species that the calyx of this species resembles, there are none described having any such vault as this one has.

Found in the chert belonging to the Burlington Group at Sedalia, Missouri, and now in the collection of S. A. Miller.

PLATYCRINUS GERMANUS, n. sp.

Plate IV, Fig. 46, side view, the spines may be foreign matter; Fig. 47, basal view, one plate is pushed a little out of place, and the spines on one belong to foreign material.

Species medium size. Calyx somewhat obpyramidal, rather rapidly expanding especially toward the arm bases, which gives to the upper part a pentagonal outline; truncated below, only to the extent of the diameter of the column; diameter about one-half more than the height; surface granular.

Basals form a cup two and a half times the diameter of the column, the lower part having a concave depression for the attachment of this column without any surrounding rim. The facets supporting the radials are slightly concave. First radials a little longer than wide, gradually expanding, convex longitudinally, depressed towards the sutures, and most tumid toward the second radials. Articulating facets directed upward at an angle of about forty five degrees, form more than half a circle, and occupy about half the diameter of each plate. Only slightly notched in the central part. Second radials short and axillary.

Vault elevated, the first interradials standing nearly upright. There are a few large spines on the summit of the specimen, but as the outlines of the plates cannot be determined it is not certain that the spines belong to it, probably they belong to foreign matter.

This species is distinguished from *P. arquilernus*, which it most resembles, by the form of the basals as well as by the proportion of the height to the diameter. The facets for the second radials are also somewhat different, and the angles for the interradials are more obtuse in that species than in this, which shows that the vaults are different, though unknown beyond those plates. It might also be compared with *P. peltisensis*, from which it may be distinguished by the form of the basal cup and the articulating facets for the second radials, and by minor details.

Found by Mr. F. A. Sampson in the Chouteau Group, at Sedalia, Missouri, and now in his collection.

Family PISOCRINIDÆ.

PISOCRINUS BACCULA, n. sp.

Plate V, Fig. 23, side view showing the small single radial; Fig. 24, side view showing the large radial; Fig. 25, basal view; Fig. 26, summit view of calyx.

Species large, quite as large as *P. campana*. Calyx somewhat bell-shaped or like a huckleberry; greatest diameter at the lower third and below the point of the small radial; abruptly rounded below and deeply concave or sunken at the columnar pit; rapidly contracted in the upper part. The specimen illustrated is not round, as seen from below, and all three of the specimens examined seem to be somewhat irregular in this respect, though each of the others is more nearly round and regular than the one illustrated. Plates thick. Surface smooth.

The five basals form almost an equilateral triangle that is not visible in a side view except at the angle below the small radial. They are abruptly bent down into the columnar cavity. The three plates in the angles are quadrilateral, the other two are triangular. There is not much difference in the size of the basals. The positions of the subradial and the five radials are

the same as in *P. gemmiformis*, the difference in size and form simply gives the difference in the shape of the calyx which is much more contracted in the superior part of this species than in that one. The form of this species is such that the arm blades must be shorter than in other species, and smaller in proportion to the size of the body, or they must spread above the mortises or articulating facets, differently from other species.

Found in the Niagara Group, near St. Paul, Indiana, and now in the collection of Wm. F. E. Gurley.

PISOCRINUS MILLIGANI, n. sp.

Plate V, Fig. 27, side view of a complete specimen which also preserves part of the column magnified two diameters; Fig. 28, basal view of the same specimen magnified two diameters. This specimen does not show the sutures in the calyx. Figs. 21, 22 and 23, on Plate VI of the 17th Report of the Geological Survey of Indiana belong to this Species.

Species medium size, larger than *P. gorbyi*, which it resembles. Calyx obpyramidal, truncated below and has a deep columnar pit, and more or less rapidly expands in the radial regions, giving to the upper part a pentalobate aspect. There is some difference among the specimens as to the proportions in length and breadth and as to the extent of the pentalobate extensions; but the specimens illustrated here and in the Indiana report are average in this respect. *P. gorbyi* is longer in proportion to the diameter than this species. Plates thick; surface smooth. Column small and round.

The five basal plates form a triangle that occupies the basal cavity and the lower part of the calyx so as to be seen in a side view even plainer than they can be in *P. gorbyi*. The subradial and radial plates are proportionally shorter and wider than in *P. gorbyi* and the lobate character more pronounced. The radials are excavated by a wide dove-tailed mortise on the lobes of the calyx, and, in the depressions between the lobes, curve in over the calyx so as to leave the summit, when the arm blades are removed, with a five-rayed star-like opening. There is no vault plate. The tenons of the

blades fill the mortises, and the blades unite, leaving only a small round opening at the center, which is continued up between the blades, but it is much contracted at the summit. Each arm blade consists of a single plate. The specimen illustrated is complete.

The arm blades are larger and stronger in this species than in *P. gorbyi*, which is a marked distinction, though the shorter and wider radials will enable any one to distinguish the species, in the absence of the arm blades.

There are, in the collection of Mrs. J. M. Milligan, five specimens of this species having the arm blades, and many specimens, in which the arm blades are not preserved; there are also specimens, without the arm blades, in the collection of the authors, all of which came from Decatur county, Tennessee. It must be apparent to any one having been a student of the Echinodermata that *Pisocrinus* is not more nearly related to the order *Palæocrinoidea* than it is to the *Blastoidea*. It has neither the arms nor the vault of a crinoid, besides being anomalous, in the arrangement of the plates of the calyx.

Found by Mrs. J. M. Milligan, in the Niagara Group, of Decatur county, Tennessee. The specific name is intended as a compliment to the lady who collected the fossils from that locality and has been a student of Natural History for many years.

THALAMOCRINIDÆ, n. fam.

This family name is proposed to receive the new genus Thalamocrinus and for the present, the family characters must be regarded the same as the generic.

THALAMOCRINUS, n. gen.

[Ety, *thalamos* a small house or den; *krinon* lily.]

Body pear-shaped or more or less fusi form, and covered by three ranges of plates and a small vault. Basals or first circle plates five, equal. Subradials or second circle of plates five. Radials or third circle of plates six. The vault is unknown but supposed to be like the vault of *Zophocrinus*. Column small. No arms. Type *T. oratus*.

This genus is only referred to the Palaeocrinoidea provisionally. Probably a new order should be established to include it and *Zophocrinus* and some other forms that are not very well understood.

THALAMOCRINUS OVATUS, n. sp.

Plate V, Fig. 29, side view; Fig. 30, azygous side; Fig. 31, summit view without the vault, magnified two diameters.

Body small, oval or pear-shaped, greatest diameter at the upper third; length one third more than the diameter; surface smooth.

The five basal plates are of equal size and about one third the length of the body. They are excavated below apparently for the attachment of a column, but the columnar canal is too minute to be seen except with a strong magnifier and even then it looks like a very minute, round orifice. The second series of plates are subradial in position and alternate with the basals. They constitute a little more than half the length of the body; four of them are hexagonal and one is heptagonal. The plates in the third range are short and five of them alternate with the subradials, while one of them truncates the heptagonal plate at the top, on the azygous side. The short plates forming this circle are beveled toward the interior at the top, and present an appearance much like *Zophocrinus*, when the vault is removed in that genus, which indicates a similarity in the vaults of the two genera.

Found by Mrs. J. M. Milligan, in the Niagara Group, in Decatur county, Tennessee, and now in her collection. There are three specimens, one is smaller than the specimen illustrated, and another is more than twice as large, so that the natural size of it is as large as the illustrations.

THALAMOCRINUS CYLINDRICUS, n. sp.

Plate V, Fig. 32, side view of two ranges of plates; Fig. 33, summit view of second range, magnified two diameters.

Body small, subcylindrical or somewhat fusiform. Length more than twice the diameter. Surface smooth. Sutures very distinct and slightly beveled.

Basals of equal size and having a length equal to the diameter of the cup. Truncated below, and under an ordinary magnifier no columnar canal is visible, though there is a cicatrix for some kind of attachment. The second circle of plates alternate with the basals and form a small cylinder having a length fully equal to the diameter. The thick plates may be

seen at the end and the small, round visceral cavity. The third circle or radial plates are destroyed in our specimen, but the facets for attachment are preserved and there is no reasonable doubt but that there are six of them.

Found by Mrs. J. M. Milligan, in the Niagara Group, in Decatur county, Tennessee, and now in her collection.

Family UNCERTAIN.

INDIANOCRINUS, n. gen.

[Ety. proper name, *Indiana*; *Krinon*, lily.]

This genus is founded upon the calyx of a single specimen and hence there are only a few characters to be ascribed to it. Basals, five. No subradials. Primary radials one by four. Arms four. No regular interradials. Azygous interradial rests between the upper sloping sides of two basals and is followed by two plates at the top of the calyx. Plates punctate. Type *I. punctatus*. This genus cannot be certainly classed in any family.

INDIANOCRINUS PUNCTATUS, n. sp.

Plate V, Fig. 8, basal view; Fig. 9, summit view; Fig. 10, lateral view, azygous side on the right; Figs. 11, 12 and 13, same views magnified two diameters.

Calyx pear-shaped; plates longitudinally convex; sutures depressed. Surface pitted or punctate. Column very small.

Basals pentagonal, elongated, truncated for a very small column and forming together a pentagonal cup, with depressed longitudinal sutures, about one-third of the height of the calyx. Primary radials longer than wide, the two adjoining the azygous area larger than the other two, most convex in the middle, at the lower edge of the articulating facets; lateral sutures deeply depressed toward the top of the calyx. Facets for the second radials a little more than one-third of the width of the plates, subelliptical in outline and deeply notched for the ambulacral canals. The angles formed, at the sutures on the superior face, between the articulating facets, are obtuse, as the superior lateral angles of the first radials curve over toward the vault.

The first azygous plate is hexagonal, as wide as long, very tumid or bulged out in the central part, rests between the upper sloping sides of two basals, separates two first radials and is followed by two plates that are not preserved in our specimen. The two superior faces are concave. The vault is unknown.

This species is extraordinary because there are only four arms; because the first azygous plate rests between the upper sloping sides of two basals, and because the plates are pitted. The specimen is well preserved and in its normal condition. The hole shown in the illustrations does not appear to pass through the test and may not properly belong to the species as a character of any importance.

Found in the Niagara Group, at St. Paul, Indiana, and now in the collection of Wm. F. E. Gurley.

ORDER CYSTOIDEA.

Family HOLOCYSTIDÆ.

HOLOCYSTITES ASPER, n. sp.

Plate V, Fig. 1, summit view; Fig. 2, anterior side view.

Body medium size, subovate most tumid on the left anterior side, plates large, convex, covered with large pastules and pierced with numerous pores; sutures deeply impressed. The specimen illustrated has the lower part broken away, so whether or not it was sessile cannot be determined, and probably two ranges of plates are gone; five ranges of plates only are preserved.

The first range of plates preserved, which is, in fact, the second or third range, consists of four large plates and four smaller ones, the latter are on the anterior side and may be seen at the bottom of figure 2. The second range has eleven plates, of unequal size; the third range has eleven plates, the fourth range six, and the fifth range, that surrounds the ambulacral orifice, at the center of the summit, has six plates. There are no intercalated plates between the ranges in our specimen.

The mouth is surrounded by five plates and is submarginal between the range that surrounds the ambulacral orifice and the next range below. Four of the plates that serround the ambulacral orfice have spine bases.

This specimen will be distinguished by its general rough form, flattened or depressed anterior side, ventricose upper part of the left anterior side, increased size and irregular outline of plates to cover the ventricose parts of the body without its intercalation of small plates between the ranges, by the number of plates in the ranges, and by the four spine-bearing summit plates. If two ranges of plates are broken off from the lower part then it is, probably, nearer to *H. ornatissimus*, than to any other species, agreeing with it in the number of ranges of plates and summit spines, but differing in the shape of the body, the position of the greater tumidity, and in the number of plates in each of the ranges below the summit.

Found in the lower part of the Niagara Group near Madison, Indiana, and now in the collection of J. F. Hammell.

HOLOCYSTITES SPHAEROIDALIS, n. sp.

Plate V, Fig. 3, summit view; Fig. 4, left side view.

Species sessile, with a large subelliptical base of attachment, that is very short. Body medium or below medium size, subspheroidal, though bulging on different parts, most tumid in the left posterior part, where it is peculiarly prolonged Plates small in the lower part, but medium size above, very slightly convex in part and plane in part, and pierced with numerous pores without any order of arrangement. Sutures not beveled and traced with some difficulty.

The first range of plates above the solid base of attachment is composed of very short, wide plates that are interrupted in the posterior part, so as not to make a complete circle. The second range is composed of small plates that are longer than wide on the front and sides, but wider on the posterior part, and form a complete circle. The third range is similar to the second, but the plates are longer. In the fourth range there are twenty-seven plates, differing somewhat in size, but all of them rather larger than wide. In the seventh range sixteen plates, four of which abut upon the oral opening or mouth, as shown in figure 3, and there is a small triangular plate that abuts upon the mouth and cuts off an angle from two of these plates. The eighth range surrounds the ambulacral

orifice and consists of eight plates, five of which bear the scars of ambulacral spines, and one is inserted between the mouth and the ambulacral orifice. The mouth is subinarginal, large and somewhat smaller than the very large ambulacral orifice, each is surrounded by eight plates.

This species will be distinguished by its general form, great number of plates, none of which are intercalated, except the triangular one that abuts upon the mouth, eight ranges, five spine bases, and sessile habit.

Found in the lower part of the Niagara Group near Madison, Indiana, and now in the collection of Mr. J. F. Hammell.

ORDER BLASTOIDEA.

FAMILY CODASTERIDÆ.

CODASTER BLAIRI, n. sp.

Plate V, Fig. 20, basal view; Fig. 21, side view; Fig. 22, summit view, one triangular field is covered with part of the matrix so that the azygous opening cannot be seen.

Calyx obpyramidal, summit convex, so that the total length, from column to summit, is equal to the greatest diameter. Transverse section of the calyx pentagonal with slightly concave sides; surface marked with numerous fine lines parallel to the sutures between the plates, except the three longitudinal sutures between the basals. Truncated at the base for a very small, round column.

There are three basals, the two larger ones are of equal size and pentagonal, the smaller one is tetragonal and each has its inner apex notched to form part of the round columnar canal. The basals form a pentagonal cup about half the height of the calyx. Radials a little wider than high, equal, truncated above, and mesial gibbosity gives the pentagonal outline to the summit. From a central, pentagonal, stelliform opening, five triangular fields radiate to the angles of the pentagonal summit. The one which is smooth and bears the anal opening, in other species, has part of the matrix attached to it in our specimen, so the anal orifice cannot be distinguished. Each of the other four triangular fields is divided by a narrow angular radiating

ridge that terminates at the lateral suture between the first radials called the "oral ridges." The pseudoambulacra are narrow and each one shows a dividing line or furrow from the central oral opening half way to the angles of the pentagon. There are eight hydrospire slits in each of the eight areas between the oral ridges and the pseudoambulacra.

The general form and eight hydrospire slits in each field will distinguish this species.

Found by R. A. Blair, in whose honor the specific name is proposed, in the Chouteau limestone near Sedalia, Missouri, and now in the collection of S. A. Miller.

SUBKINGDOM CŒLENTERATA.

Class ANTHOZOA.

Subclass ZOANTHARIA.

Family ZAPHRENTIDÆ.

HADROPHYLLUM TENNESSEENSE, n. sp.

Plate V, Fig. 16, summit view of a slightly convex specimen; Fig. 18, summit view of a more convex specimen; Fig. 17, lateral view of same; Fig 19, basal view.

Corallum medium size, short, longitudinally double convex, transversely elliptical. Calyx convex, sometimes very highly convex and having a flattened or slightly concave central area, the greater convexity is opposite the septal fossette and above the place of attachment or commencement of growth. A thickened septa occupies the center of the septal fossette running with the longer diameter of the calyx from the central part to the border; the septal fossette extends around the central end of the thickened septa and its sides, from which the lateral septa radiate to the border. The lateral fossettes are inconspicuous, but are indicated by a depression from the center to the lateral borders. The radiating septa are unequally developed, those upon the sides of the septal fossette are much shorter than the others. There are from twenty-two to twenty-six in the specimens examined. The point of attachment or place of commencement of growth is subcentral or below one

of the foci of the ellipse formed by the calicular border. From a short elliptical base the corallum is abruptly expanded to the calicular border.

The length of a specimen is about three-tenths of an inch; shorter diameter of the calyx about four-tenths of an inch, and longer diameter of the calyx about six-tenths of an inch. Our specimens are silicified and do not show any epitheca, dissepiments, tabulæ or columella.

Found in the Silicified Subcarboniferous beds of Lincoln county, Tennessee, which we suppose are of the age of the Keokuk Group, and now in the collection of Wm. F. E. Gurley.

CLASS, CEPHALOPODA.

ORDER, NAUTILOIDEA.

Family CYRTOCERATIDÆ.

CYRTOCERAS KANSASENSE, n. sp.

Plate V, Fig. 5, ventral view; Fig. 6, lateral view; Fig. 7, position of the siphuncle and convexity of the septa at the fifth air chamber that is preserved, in the specimen illustrated.

Our specimen is not complete and shows the siphuncle and convexity of the septa at the small end; and has been broken at the fifth septa, so that it may be examined in two places, and figure 7 is taken from a view at the fifth septa.

The shell rapidly expands, is gently curved, and slightly depressed from a true circle, in tranverse section, on the ventral side. The outer shell is preserved forward of the fifth septa, so that only five air chambers can be seen, but the end of the siphuncle indicates there are air chambers forward of that point. The siphuncle is small and near the ventral side, the expansion within the air chambers is not disclosed. The convexity of the septa is rather more than the length of an air chamber. The septa are distant about one-fifth the diameter of the shell. The outer shell is transversely furrowed. On the ventral side the spaces between the furrows are flattened and wider than the furrows. On the dorsal side the furrows and ridges are subequal. The body chamber is not completely preserved, and the aperture, therefore, is unknown.

This species is quite distinct from all others in almost every respect and may not belong to *Cyrtoceras*. When compared with *C. dilatatum*, it will be noticed that the surface is furrowed instead of imbricated and the septa are not half as numerous. It is not necessary to draw comparisons with other species.

Found in the Upper Coal Measures, at Kansas City, Missouri, and now in the collection of Wm. F. E. Gurley.

SUBKINGDOM ARTICULATA.

CLASS ANNELIDA.

ORDER TUBICOLA.

Family SERPULIDÆ.

SPIRORBIS BLAIRI, n. sp.

Pplate V, Fig. 15, a coil attached to Platystoma broadheadi; Fig. 14, an old specimen with the anterior end prolonged upward.

Shell sinistral and in its young state attached throughout its length. Umbilicus wide. Surface marked with unequally distant rings of growth. In an old specimen, as shown by Figure 14, the anterior end is prolonged and stands upright. The lower side of the shell, that attached to some foreign object is flattened, otherwise a transverse section is circular. The aperture seems, in all stages of growth, to have been directed upward and when a complete coil, for attachment, had been formed the further growth was in the form of a loose spiral or upright tube.

Five specimens belonging to this species have been examined and the growth of the spiral in all cases, was to the left as sinistral. About one coil and a quarter or less than one turn and a half attached to the foreign substance. The transverse ridges are closer and finer on some specimens than upon others, but always more or less irregular, and sometimes quite coarse and wavy, indicating lines of growth, rather than surface ornamentation.

This species is distinguished by its sinistral growth, freedom towards the aparture, and surface lines of growth.

Found in the Choutean limestone, at Sedalia, Missouri, and now in the collection of S. A. Miller. The specific name is in honor of R. A. Blair, the original collector.

PLATE I.

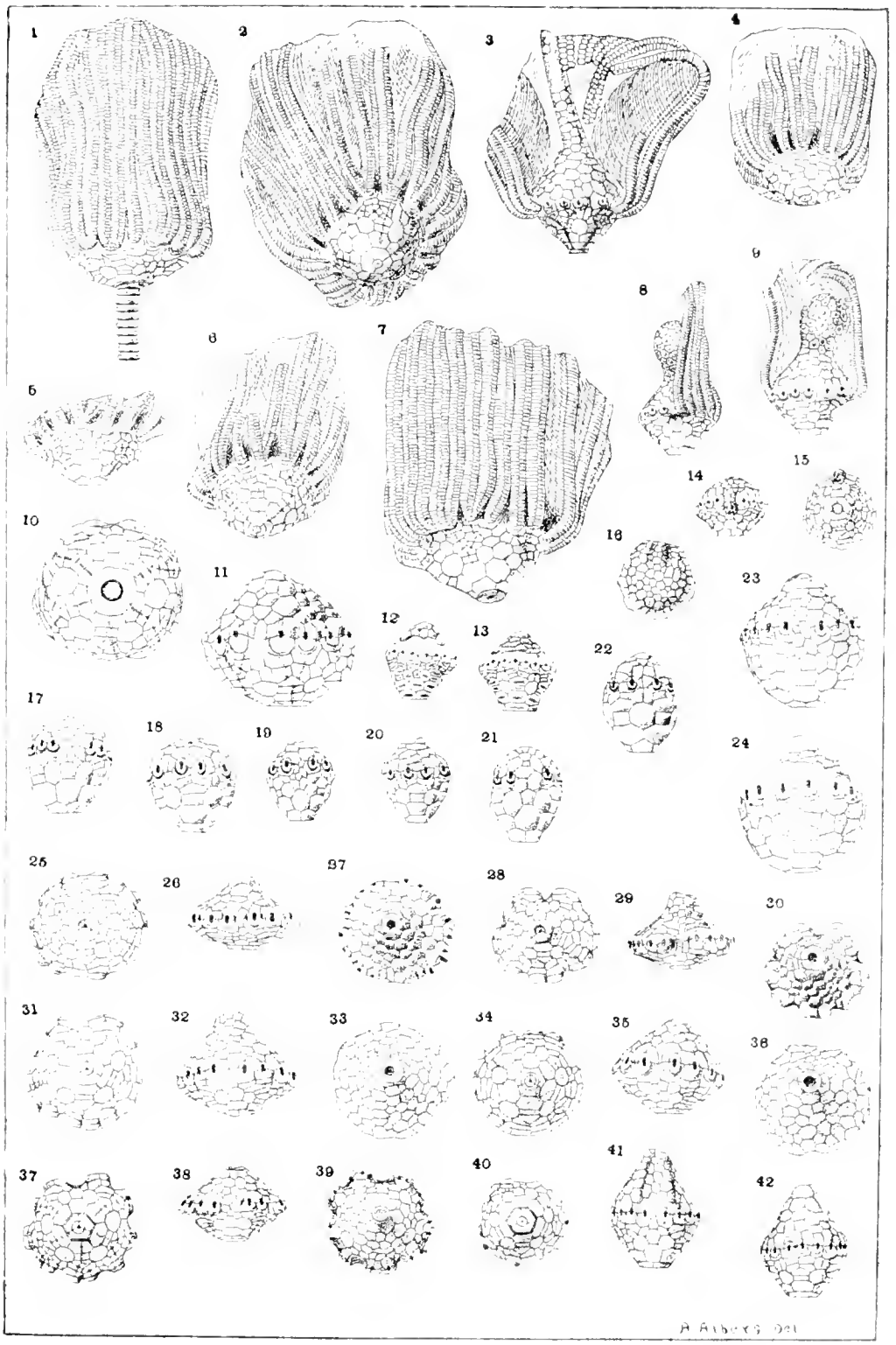
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PLATE II.

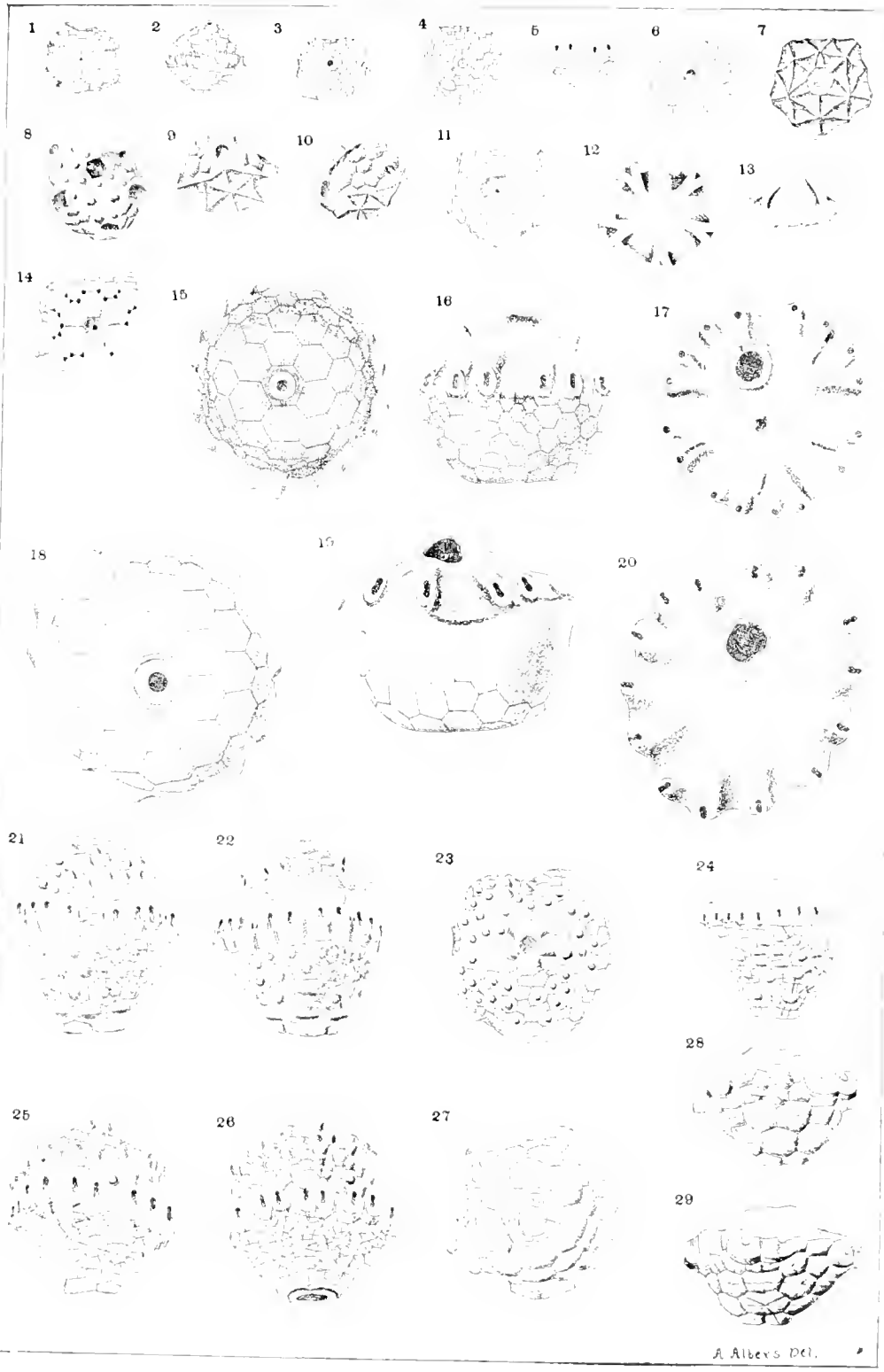
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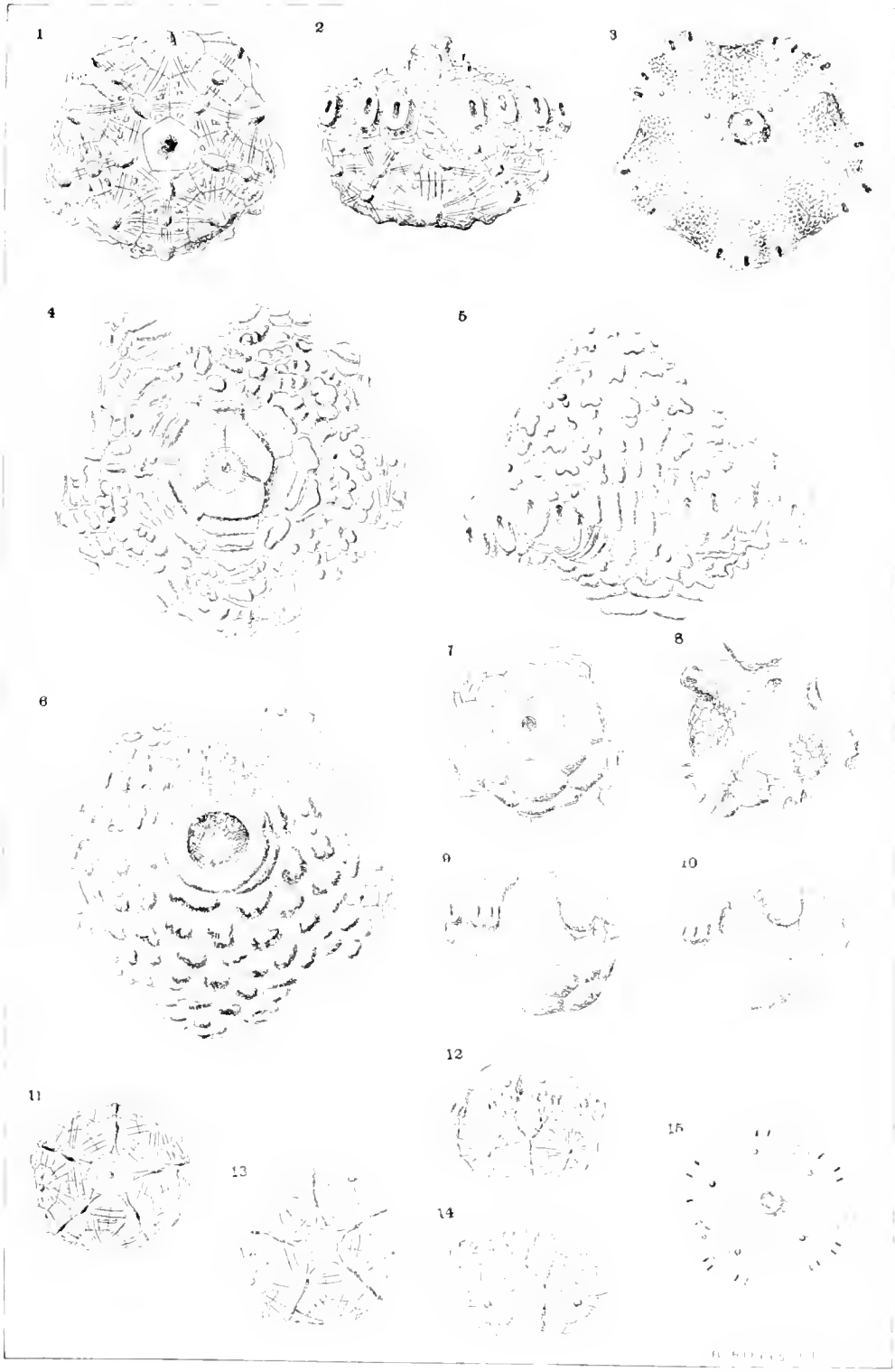
PLATE III.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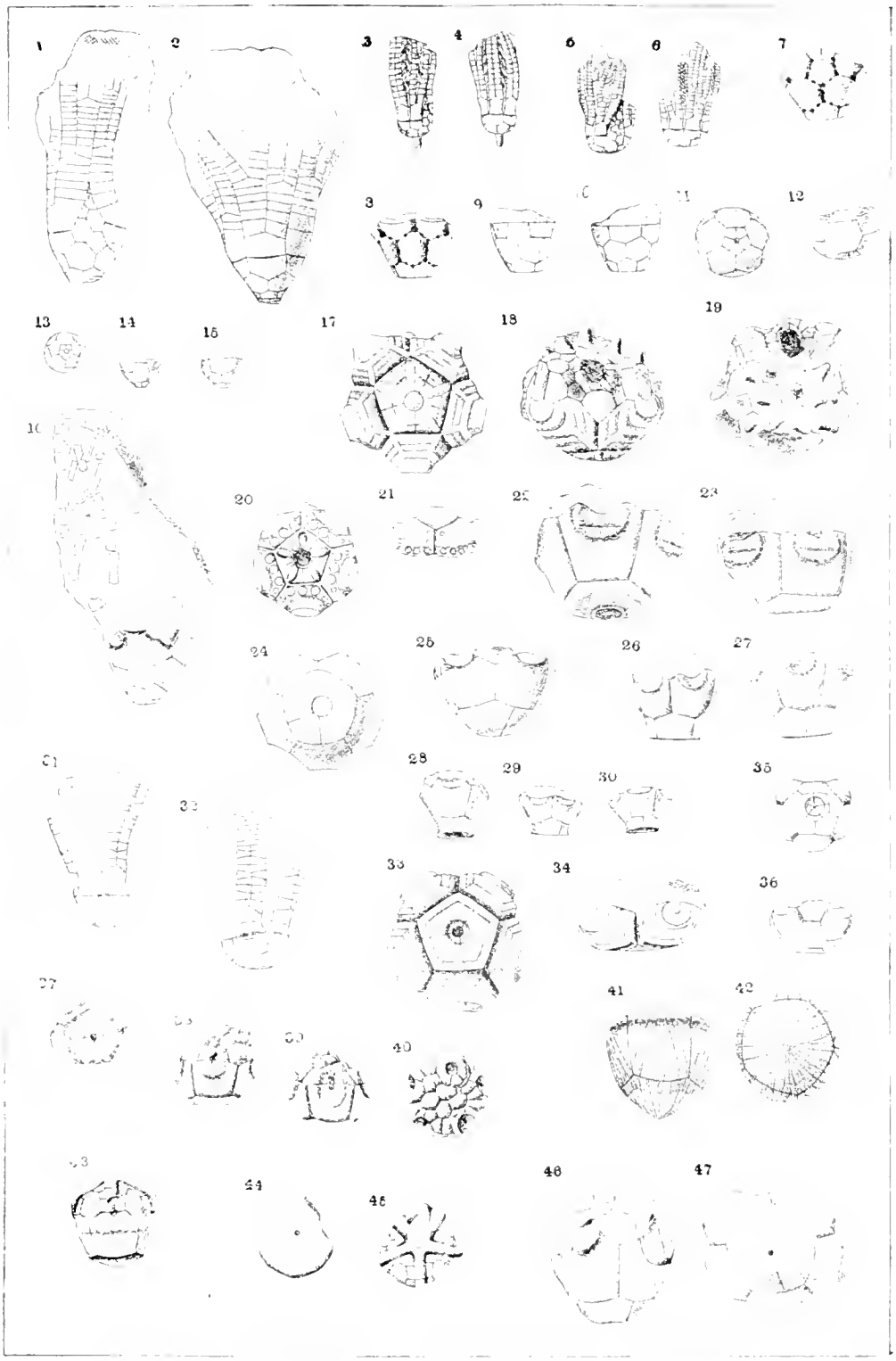
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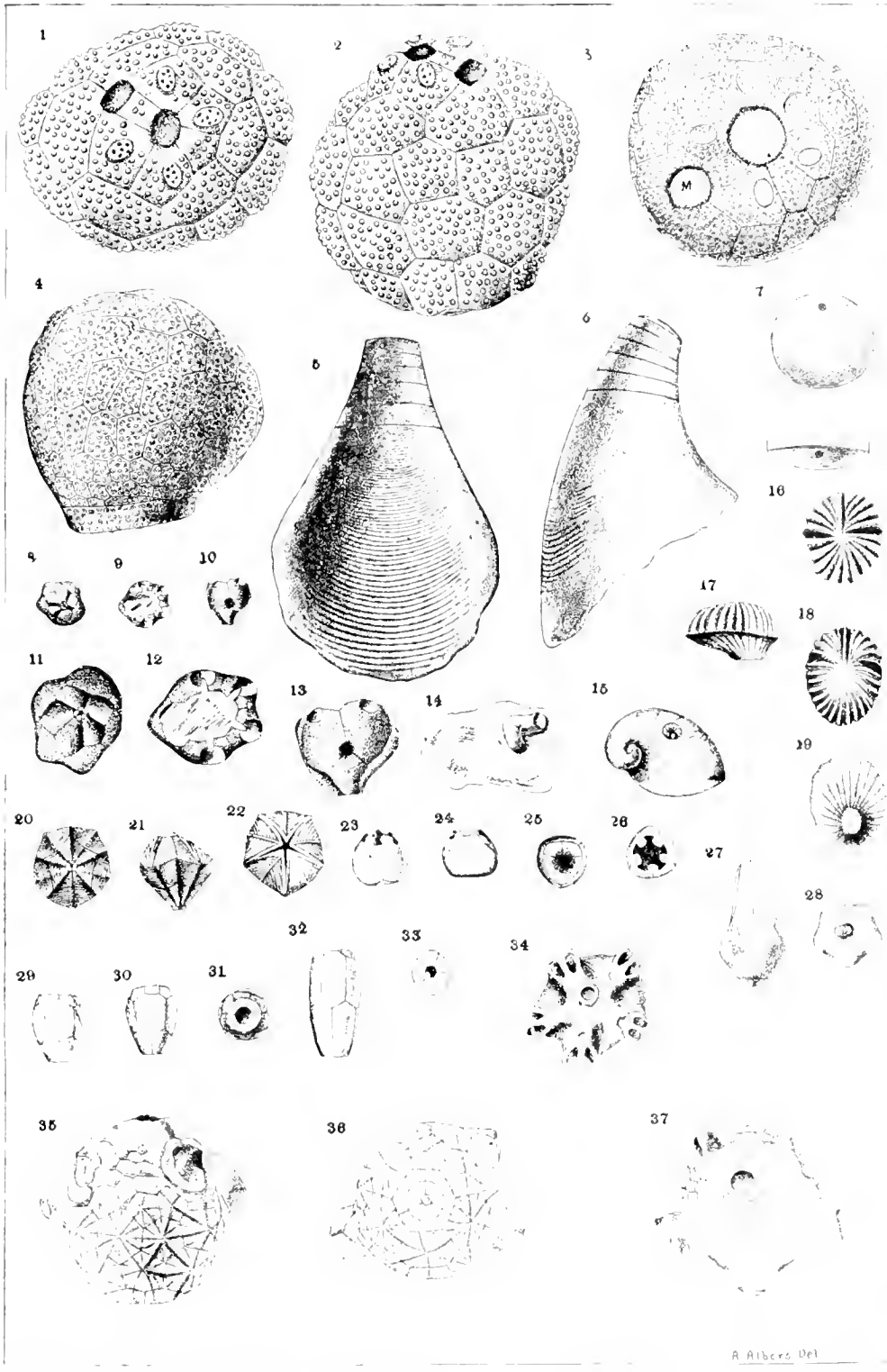
PLATE V.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