Crinoid Fauna of the Hampton Formation at LeGrand, Iowa

L.R. Laudon

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The Crinoid Fauna of the Hampton Formation at LeGrand, Iowa

by

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University of Tulsa, Tulsa, Oklahoma

AND

B. H. Beane
LeGrand, Iowa

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CONTENTS

THE CRINOID FAUNA OF THE HAMPTON FORMATION AT LEGRAND, IOWA

Abstract

The Kinderhook limestone at LeGrand, Iowa, has long been famous for its excellently preserved crinoid fauna. Continuous work in the area for over forty years has accumulated a large number of specimens of most of the originally described species and a considerable number of specimens representing new species. On the basis of this wealth of material, it is the purpose of this paper to bring all existing information up to date. Forty species of fossil crinoids are recognized in the fauna, eleven of which are new.

Introduction

The last descriptions of fossil crinoids from the crinoid bearing Kinderhook beds at LeGrand, Iowa, appeared in 1897 in Wachsmuth and Springer's (17) monograph on camerate crinoids. Since that time the junior author of this paper has been in residence at LeGrand, Iowa, and has been in constant contact with the quarrying operations of the region. Since almost all of the original species came from a single colony, it is not at all surprising that continuous work in other parts of the section has resulted in the accumulation of a number of new species of crinoids. Many of the originally described species are now represented by hundreds of specimens in all stages of maturity, so that it is now possible to clear up many points left in question in the first descriptions. The present paper is designed to completely re-classify and describe if necessary the original species and to bring up to date any existing knowledge with regard to newly discovered forms.

Previous Work

Fossil crinoids were first collected in the Kinderhook strata at LeGrand, Iowa, by Hall (3) in 1858. Reference is again made to the fossiliferous strata at LeGrand by White (14) in his report on the geology of Iowa in 1870. These early references to fossil crinoids at LeGrand were made from scattered specimens discovered at

random in the area. It was not until June, 1874, that the discovery colony was located in the soft dolomitic limestone layers that occur in the middle portion of the section. Since quarrying operations were conducted entirely by hand at this time, the process of removal of the crinoids from the colony was continued through several years. Crinoids were still available from this colony as late as 1890.

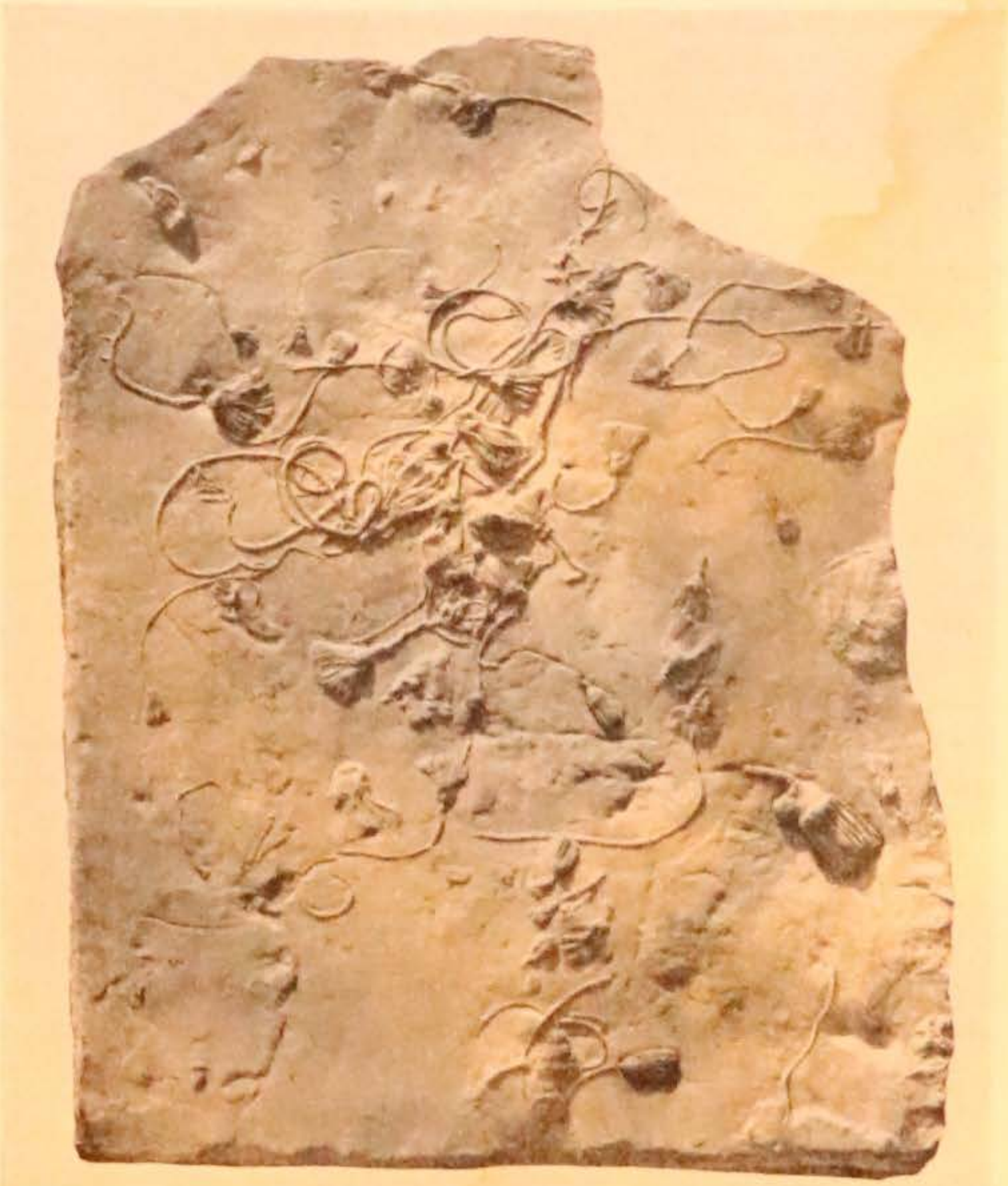

Figure 1. Typical slab of fossil crinoids from the original discovery colony. This slab carries 47 specimens of crinoids distributed among 11 species. B. H. Beane collection.

During the years between 1874 and 1890, several excellent collections of crinoids were made by enthusiastic students of natural history who resided in Marshalltown and LeGrand. Chief among the individuals to be remembered for their excellent work in collecting and preserving these fossil crinoids are: Hon. Delos Arnold, Dr. W. B. Waters, and Dr. W. S. McBride of Marshalltown; Louis Hammond and John McCabe of LeGrand. At this time the quarry was owned and operated by George F. Kirby and H. J. Howe of Marshalltown. It was only through the very fine co-operation between these gentlemen and the early collectors that so many of these excellent crinoids were saved from the crusher.

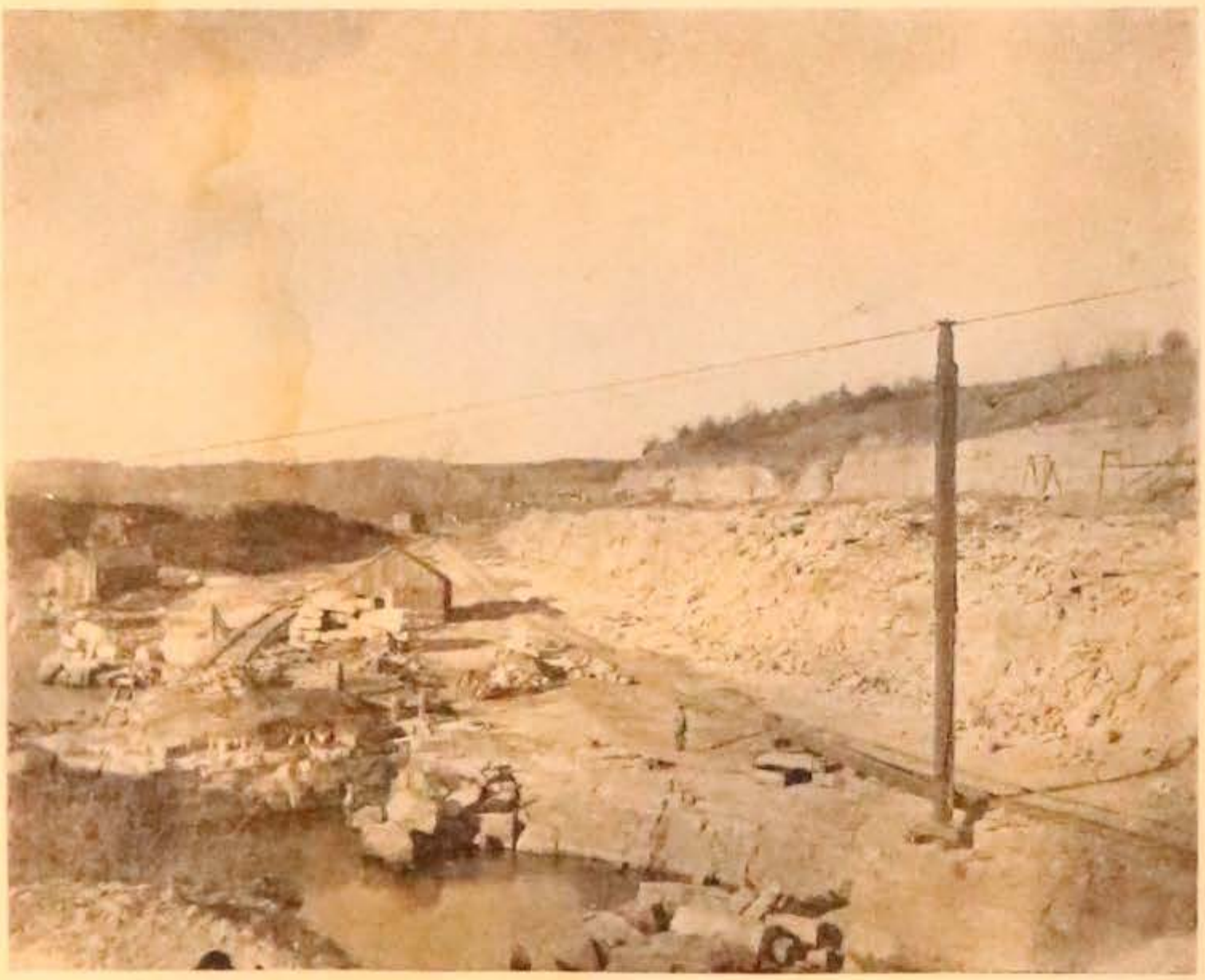

Figure 2. The Quarry at LeGrand at the time of the original discovery of the colony of crinoids.

The first descriptions of species of crinoids from LeGrand were made by Miller and Gurley (8) in June, 1890. They were followed in July, 1890, with descriptions of species by Wachsmuth and Springer (15). Another group of species was described in 1894 again by Miller and Gurley (9). The final descriptions came with

the publication of Wachsmuth and Springer's (17) monograph on the camerate crinoids.

After the exhaustion of the first colony, very few crinoids of importance, with the exception of scattered specimens, were found until the summer of 1931. A small colony consisting to a great extent of specimens of *Rhodocrinus kirbyi* was blasted out at this time. Slabs from this colony have since proved to be the most spectacular, as far as abundance and excellent preservation is concerned, yet discovered. Several small slabs of less than three feet in diameter have as many as 200 excellently preserved crinoids on them.

Figure 3. Typical slab from the second colony showing a profusion of specimens of *Rhodocrinus kirbyi*. The slab carries 206 specimens distributed among 9 species with *R. kirbyi* by far the dominating form. B. H. Beane collection.

A short distance from the *Rhodocrinus* colony a single slab with 183 excellently preserved starfishes was discovered. The fossils are clustered in a depression on the surface of the limestone approximately five feet in length and three feet in width. Both oral and aboral surfaces are excellently shown in many cases. They are apparently typical examples of *Schoenaster legrandensis* which was described by Miller and Gurley (8) from a fragmentary imperfect specimen. A new genus and species *Iovaster grandis* has

Figure 4. A slab of LeGrand limestone carrying 183 specimens of *Schoenaster legrandensis*, 12 echinoids, 1 crinoid, and 2 trilobites. B. H. Beane collection.

recently been established by Keyes (4) for the form. Since the fossils exhibit all of the characteristics of the genus *Schoenaster* and agree in all parts with the fragmentary form described by Miller and Gurley, there is little reason for recognition of the new genus and species *Iovaster grandis* as described by Keyes.

Another spectacular discovery was made during the summer of 1933, when, after an unusually strong blast the slabs carrying crinoids were found scattered over a considerable portion of the quarry floor. Later work on the face of the quarry immediately back of the area in which the slabs were found, showed that only the outer portion of the colony had been blasted out. The length of the colony along the face of the quarry was about 20 feet. Sev-

Figure 5. Typical slab from the large colony located during the summer of 1933. This slab carries 108 crinoids distributed among 16 species. B. H. Beane collection.

eral thousand excellent specimens were collected from the material that was taken from the floor of the quarry. Many of these slabs were far superior to any taken from the original colony.

Plans were laid to blast and quarry down to this layer at the close of the quarrying operations in 1934. Accordingly, the top material was blasted off and men put to work removing the loose material down to the massive ledge immediately above the fossils. With the aid of bars and jack screws the massive ledge was moved enough to allow the thin soft dolomitic layers containing the crinoids to be removed. Again several thousand excellent specimens were obtained.

Operations of the northwestern quarry during the summer of 1937 blasted out the remaining portion of the colony. With the excellent co-operation of superintendent B. K. Baumgardner, the major portion of this last portion of the colony was saved.

Location of Area

With the exception of a few scattered specimens, the crinoids have been collected from a restricted area in the large south quarry at LeGrand. The exposures of the Hampton formation at LeGrand are located in the bluffs of Iowa river a short distance north of the town. The large south quarry is located one mile north and west of the edge of LeGrand in the SW. quarter of sec. 1, R. 17 W., T. 83 N.

The abundant occurrence of crinoids is as yet confined to the south half of the quarry face. Scattered specimens occur at almost any portion of the south half of the quarry. The three main colonies, however, have all come from a restricted area covering not over 100 feet of the quarry face. Location of this area is rather difficult because the quarry face is constantly being altered. Original quarrying in the area was carried on in the underlying oolitic limestone as well as in the softer overlying dolomitic limestone beds. Later, quarrying in the oolitic limestone was abandoned and consequently the old quarry hole down through the oolite is an easily recognizable landmark in the south end of the quarry. The original colony of crinoids was located directly east of the middle of the north half of the old oolitic limestone quarry hole. The later colonies have been located from about 75 to 100 feet respectively north of a line drawn east and west through the original colony.

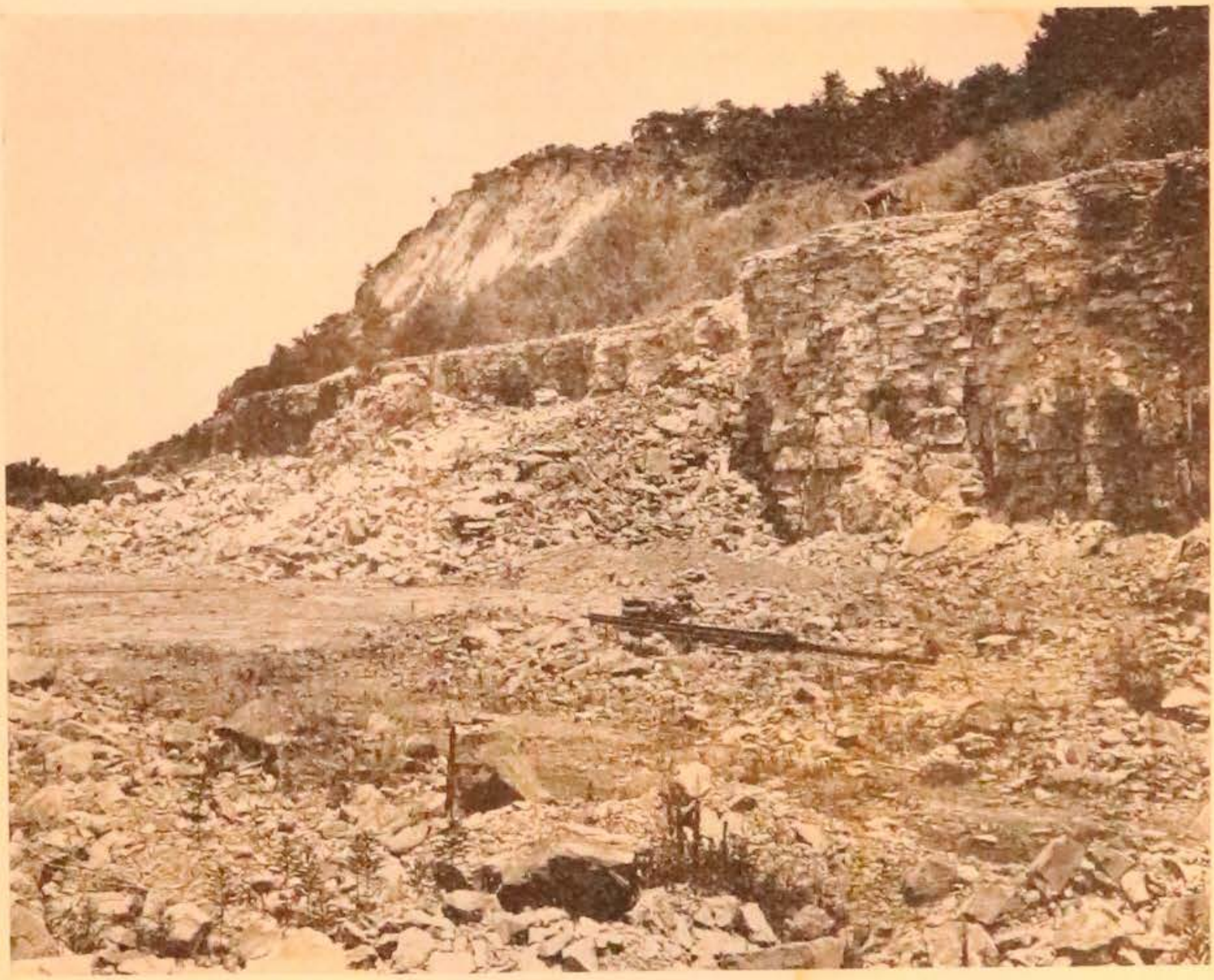

Figure 6. South quarry at LeGrand during the summer of 1937. Crinoids taken from the newly blasted rock in the immediate foreground.

Stratigraphy

The term Hampton was introduced in 1929 by Laudon (5) for the Kinderhook strata lying above the English River formation and below the Gilmore City limestone. This description of the Hampton formation definitely included portions of the Kinderhook of Iowa that are to be correlated directly with the Chouteau limestone of Missouri. The Hampton formation was divided into two members as exposed in southeastern Iowa, the North Hill at the base, and the Wassonville above. In the northern province the Hampton was divided into four members, from the base upwards: Chapin, Maynes Creek, Eagle City, and Iowa Falls. A recent study of the distribution and stratigraphy of the various members makes it apparent that the North Hill member of the southeastern province and the

lower portion of the Chapin member of the northern province are direct correlatives of the Chouteau of Missouri and should not be considered as a part of the Hampton formation. The overlying limestone and dolomite of the Maynes Creek, Eagle City, and Iowa Falls is much more closely related to the overlying Gilmore City formation than to the underlying Chouteau limestone. Accordingly the term Hampton was restricted by Laudon (7) to the dolomitic upper portion of the Chapin, the Maynes Creek, Eagle City and Iowa Falls members in the northern province and to the Wassonville member in the southeastern province. The section carrying the crinoids at LeGrand is seen to lie near the base of the restricted Hampton formation. The typical Wassonville chert fauna is found in the lower portion of the section at LeGrand.

Location of the main crinoid bearing strata at LeGrand is not difficult after a minor amount of field experience in the quarries.

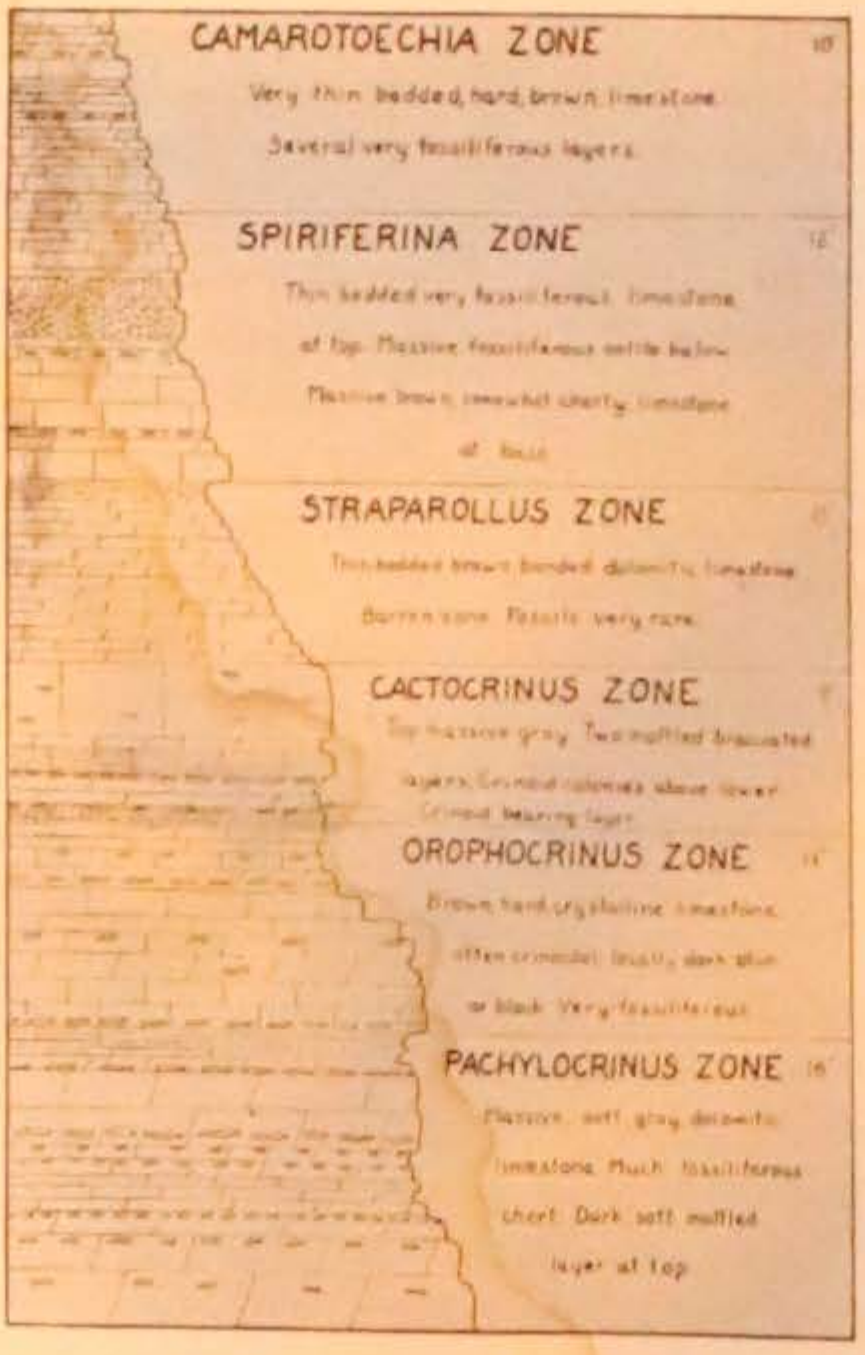

Figure 7. Hampton formation as exposed at LeGrand.

Apparently all large colonies are confined to one narrow zone that is conveniently marked by peculiar mottled limestone conglomerate ledges that lie both above and below the soft fossiliferous beds. A consistent band of chert usually lies just above the crinoid bearing strata in the soft dolomite just below the upper limestone conglomerate. The soft dolomitic layers that carry the fossils are never over 10 inches in thickness. The fossils themselves are usually confined to one plane in the bed. They lie in depressions on the limestone surface and are usually within slabs making it necessary to split the rock before the fossils may be worked out. They are detected as rows of stems and fractured crowns along the sides of the slabs. When the individuals are not abundant, very careful observation is necessary to detect the cross sections of the stems.

Preservation of Crinoids

Crinoids as preserved at LeGrand are definitely gregarious, occuring profusely in circular lenticular masses in depressions on the limestone surface. Because of the excellence of preservation and complete absence of orientation in their long directions, it is assumed that they lived in quiet water. The thin bedded evenly laminated dolomitic limestone suggests that they were not rapidly buried. Why these small areas were spared by the shell feeding sharks is difficult to answer since shark remains are abundant throughout the formation. None of the LeGrand forms carry stump-like root systems. The slender tapering columns usually bear cirri over a considerable portion of their lower extremities suggesting the possibility of mobility. They often appear to be more adapted for grasping than for rooting to the bottom. In every case the column and cirri are lying flat on the preserving surface and definitely do not run through the bedding planes of the limestone.

Acknowledgments

The writers wish to acknowledge the excellent work of Miss Annette Chronic, art student of Tulsa University, through whose efforts many of the more difficult illustrations have been prepared.

We also wish to acknowledge the work of Mr. C. T. Kohn, geologic artist of Tulsa, Oklahoma, who prepared many of the illustrations which appear in this paper.

Sincere thanks are due to the officials of Northwestern Railway Company and particularly to superintendent B. K. Baumgardner,

for their excellent and wholehearted co-operation in removing the fossils from the ledges.

Valuable assistance has been freely given by the following men of LeGrand, Iowa: Corwin O'Neil, Donald Radloff, Cleo Lamb, Glen Smaha, Truman Manship, Louis Beane, Raymond Beane, Ralph Beane, and Millard Dillman.

Description of Species

Phylum ECHINODERMATA
Superclass PELMATOZOA
Class CRINOIDEA
Order CAMERATA

Family RHODOCRINIDAE Roemer

Genus RHODOCRINUS Miller

RHODOCRINUS KIRBYI Wachsmuth and Springer
Plate XV, figure 7

Rhodocrinus kirbyi WACHSMUTH and SPRINGER, *1890*, Illinois Geological Survey, vol. VIII, p. 180, pl. 15, fig. 10, pl. 16, fig. 3. — *1892*, Crinoidea Camerata, Mem. Mus. of Comp. Zool. Harvard Univ., vol. XX, p. 226, pl. XII, figs. 1a, b, c, and d.

R. kirbyi is without doubt the most abundantly occurring species in the LeGrand fauna. It is easily distinguishable from most of the other species in the fauna because of its very dark color. The calyx expands slowly, is widest at arm bases, and the interbrachial areas are filled with an exceptionally large number of plates. *R. kirbyi* is distinguishable from *R. octadactylus* n. sp. which carries eight arms to each ray instead of the usual six. *R. douglassi* var. *haploformis* n. var. is also dark in color but has an inflated calyx and a constricted pentagonal ventral disk.

Types. — United States National Museum, Springer collection. University of Iowa, Topotypes 2096, 2097, 2098, 2099.

RHODOCRINUS NANUS Meek and Worthen
Plate XV, figures 4, 5

Rhodocrinus nanus MEEK and WORTHEN, *1869*, Illinois Geol. Survey, vol. III, p. 476, pl. 18, figs. 2a, b. — WACHSMUTH and SPRINGER, *1890*, Illinois Geol. Survey, vol. VIII, p. 182, pl. XVI, fig. 4, pl. XVII, fig. 15 — *1897*, Crinoidea Camerata, Mem. Mus. of Comp. Zool. Harvard Univ., vol. XX, p. 228, pl. 12, fig. 2a, b.

This species is not an abundantly occurring form in the LeGrand fauna. It is easily distinguished from other species in that it is characterized by a very light color. All other species are darker. It is separated from *R. kirbyi* in that its calyx expands much more abruptly, the interbrachial series are much less well defined, and normally the ray plates are raised into a sharp continuous ridge. Both specimens figured in Crinoidea Camerata by Wachsmuth and

Springer (17, pl. XII, fig. 2a.) are decidedly non-typical of the species.

Types. — Peabody Museum, Harvard University. University of Iowa Topotypes 2100, 2101.

RHODOCRINUS NANUS var. GLYPTOFORMIS n. var.

Plate XV, figures 6, 10, 11

This variety is a progressive form of *R. nanus* exhibiting the same pentagonal outline and the same raised ridge running up each ray. The anal interradius is excellently defined with the opening at the summit of a high pyramid. The color is midway between that of *R. nanus* and *R. kirbyi*.

Dorsal cup. — IBB small, confined to BB concavity, protruding slightly beyond column. BB width 4 mm., height 2.5 mm. RR smaller than BB, height equals width. IBr two, IIBr one, followed by free arm plates. iBr_1 resting on truncated upper surface of BB followed by 233 or 333 in succeeding cycles. X interradius wide, normal succession X3343. X hexagonal, followed by a series which culminates in the high pyramid.

Ventral disk. — Arm openings laterally directed from projecting areas. Amb raised in ridge on ventral disk. iAmb depressed. X opening at top of eccentric high pyramid.

Arms. — Six to the ray, branching on $IIIBr_4$ or $IIIBr_5$, and on $IVBr_2$ or $IVBr_3$, biserial, brachials short, pinnules closely packed.

Column. — Round, a typical *Rhodocrinus* column.

Relationships. — Closely related to *R. nanus*, differing in that the calyx expands more rapidly, the iBr areas are broader, often with three plates following iBr_1. *R. nanus* as figured in Crinoidea Camerata by Wachsmuth and Springer (17 pl. XII, fig. 2b.) is an excellent example of this variety.

Types. — United States National Museum, Springer collection. University of Iowa, Syntype 2102.

RHODOCRINUS WATERSIANUS Wachsmuth and Springer

Plate XV, figure 1

Rhodocrinus watersianus WACHSMUTH and SPRINGER, *1890*. Illinois Geol. Survey, vol. VIII, p. 184, pl. XVII, fig. 16. — *1897*, Crinoidea Camerata, Mem. Mus. of Comp. Zool. Harvard Univ., vol. XX, p. 221, pl. XII, fig. 9.

This species is small, smooth plated, intermediate in color between *R. kirbyi* and *R. nanus*. It is characterized by having only

four arms to each ray. Occasionally five are found on each of the posterior rays, the extra arm being added on the posterior side. The anterior ray occasionally carries only two arms.

Types. — United States National Museum, Springer collection, University of Iowa, Topotypes 2103, 2104.

RHODOCRINUS OCTADACTYLUS n. sp.

Plate XV, figures 8, 9

This species of *Rhodocrinus* is very closely related to *R. kirbyi*. The calyx, while the same shape, is consistently larger, and each ray carries 8 arms instead of the usual 6. The holotype is 28 mm. from arm tips to calyx base; 15 mm. wide at arm bases; dorsal cup 9 mm. high.

Dorsal cup. — IBB small, hidden in BB concavity, BB conspicuously large. RR half the size of BB. IBr two, smaller than RR. IIBr two, supporting free arm plates. RR separated all around. Primary iBr resting on BB between two RR. Interradius normally 1332. X interradius differentiated with difficulty, slightly wider than normal iBr areas. Two small iIIBr appear in the calyx.

Ventral Disk. — Composed of small irregular pieces, anal opening slightly eccentric.

Arms. — Biserial, short, 8 to ray, 40 to the species. 19 mm. in length on holotype. Branching once on the $IIBr_2$, and again on the $IIIBr_2$. Br short and wide, concentrating the branching close to the calyx. Pinnules slender, closely packed.

Column. — Round with alternate columnals slightly expanded. A typical *Rhodocrinus* column.

Relationships. — Closely related to *R. kirbyi* which carries 30 arms instead of 40. In *R. kirbyi* the arms branch for the first time on $IIBr_3$ instead of $IIBr_2$. The Br in the arms of *R. kirbyi* are higher and narrower than in *R. octadactylus*.

Types. — University of Iowa, Holotype 2105, Paratype 2106.

RHODOCRINUS DOUGLASSI var. HAPLOFORMIS n. var.

Plate XV, figure 12

This species marks the beginning of the *R. douglassi* group that occurred so profusely in the Gilmore City formation of Iowa. It carries all of the distinguishing characteristics of the group although none are as yet well defined. Calyx round, expanding rapidly from BB, definitely constricted at arm bases. Ventral disk pentagonal,

holotype 14 mm. in width, and 12 mm. in height. Known from 4 specimens.

Dorsal cup. — IBB small, confined to BB concavity. BB forming part of BB concavity and lower portion of lateral calyx wall, wider than high. RR, width 4 mm., height 5 mm., normally heptagonal. IBr two, of about equal size, second axillary, normally hexagonal. IIBr one, occupying lower edge of depressed ambulacral opening. iBr_1 pentagonal, resting on the truncated upper surface of the BB, followed by 2322, occasionally 2332. X interradius wide, well defined. X hexagonal, resting on truncated posterior BB, followed by a continuous row of large conspicuous pieces. X interradius bulging, normally X3333.

Ventral disk. — Pentagonal, flattened on top, arm openings laterally directed. Corners of pentagon immediately above rays. Plates large, well defined. O large. X opening slightly eccentric, located in a raised pyramid.

The arms and column are not preserved on any of the specimens.

Types. — University of Iowa, Holotype, 2107, Paratype, 2108.

RHODOCRINUS WORTHENI Hall

Plate XV, figures 2, 3

Rhodocrinus wortheni HALL, *1858*, Iowa Geol. Survey, vol. 1, pt. 2, p. 556, pl. 9, fig. 8. — WACHSMUTH and SPRINGER, *1881*. Revision of the Paleocrinoidea, pt. 2, p. 220. — *1897*, Mem. Mus. Comp. Zool. Harvard Univ., No. 9, vol. I, p. 220. — LAUDON, *1933*, Univ. of Iowa Studies in Nat. Hist., vol. XV, No. 2, p. 38, pl. 1, figs. 2, 3.

R. wortheni has a small, smooth-plated, globose calyx similar to that of *R. watersianus*. It is distinguished from *R. watersianus* in that it carries six arms to each ray instead of four. There is little question but that *R. wortheni* is but a progressive stage of development of the more simple *R. watersianus*. In the Gilmore City (6) fauna of Iowa, transitional stages between the two species are seen. *R. watersianus* may be defined to include all specimens which carry four arms to the ray. Occasionally an extra arm is added to each side of the posterior rays making a 22 armed form instead of twenty. These may also be considered as *R. watersianus*. Specimens carrying more than 22 arms are to be classified as *R. wortheni*.

Types. — University of Iowa, Topotype 2109.

Family BATOCRINIDAE Wachsmuth and Springer

Genus BATOCRINUS Casseday

BATOCRINUS MACBRIDEI Wachsmuth and Springer
Plate XV, figures 13, 14

Batocrinus macbridei WACHSMUTH and SPRINGER, *1890*. — Illinois Geol. Survey, vol. VIII, p. 172, pl. 17, fig. 11, 12. — S. A. MILLER, *1890*, North American Geol. and Paleontology, p. 228, fig. 253. — WACHSMUTH and SPRINGER, *1897*, Crinoidea Camerata, Mem. Mus. of Comp. Zool. Harvard Univ., vol. XXI, p. 276, pl. 30, figs. 1, 2, 3.

This species is one of the rarely occurring forms in the fauna and is often confused with *Aorocrinus immaturus*. The calyx of *Batocrinus macbridei* is globose, the primary interbrachial is smaller and there are usually 3 cycles of plates in the interbrachial series below the arm bases. iBr not connected with iAmb of ventral disk. arms not grouped. X side not well differentiated, 4 cycles of plates visible in X interradius below arm bases.

Types. — Springer Collection, United States National Museum. University of Iowa, Topotypes 2110, 2111.

BATOCRINUS POCULUM Miller and Gurley
Plate XV, figure 15

Batocrinus poculum MILLER and GURLEY, *1890*, Description of New Species and Genera of Echinoidea, p. 34, pl. 6, figs. 6, 7. — WACHSMUTH and SPRINGER, *1897*, Crinoidea Camerata, Mem. Mus. Comp. Zool. Harvard Univ., vol. XXI, p. 378, pl. 30, fig. 6.

A very rarely occurring, globose, smooth plated species of *Batocrinus* with very short arms. During all of the recent collecting in the area only one specimen has been found which may be referred to this species. The arms are broken on this specimen so that their length is indeterminable. The calyx is in general larger than that of *B. macbridei*.

Types. — Walker Museum, University of Chicago — Gurley Collection, University of Iowa, Topotype 2112.

Genus AOROCRINUS Wachsmuth and Springer

AOROCRINUS IMMATURUS (Wachsmuth and Springer)
Plate XV, figure 17, Plate XVII, figure 1

Dorycrinus immaturus WACHSMUTH and SPRINGER, *1890*, Illinois Geol. Survey, vol. VIII, p. 175, pl. 16, fig. 5, pl. 17,

figs. 6, 17. — S. A. MILLER, *1890*, North American Geology and Paleontology, p. 240, fig. 280.

Aorocrinus immaturus WACHSMUTH and SPRINGER, *1897*, Crinoidea Camerata, Mem. Mus. Comp. Zool. Harvard Univ., vol. 21, p. 471, pl. XLV, figs. 4a, b.

An abundantly occurring species, represented by large numbers of excellently preserved specimens ranging from very immature to full grown individuals. Easily differentiated from *A. radiatus*, which has stellate plate markings and a fewer number of arms. Separated from *A. parvibasis* which has a smaller number of arms.

Calyx evenly expanding, conical in shape, widest at arm bases. Carrying four arms to the ray, making a 20 armed form. Occasionally 18 arms, when anterior ray carries only 2 arms. Edges of plates delicately milled and fluted in well preserved forms.

Types. — Springer Collection, United States National Museum. University of Iowa, Topotypes 2113, 2114, 2115, 2116.

AOROCRINUS PARVIBASIS (Wachsmuth and Springer)
Plate XV, figure 16

Dorycrinus parvibasis WACHSMUTH and SPRINGER, *1890*, Illinois Geol. Survey, vol. VIII, p. 177, pl. 17, figs. 7, 9, 9a. — S. A. MILLER, *1890*, N. Amer. Geol. and Paleontology, p. 240.

Aorocrinus parvibasis WACHSMUTH and SPRINGER, *1897*, Crinoidea Camerata, Mem. Mus. Comp. Zool. Harvard Univ., vol. 21, p. 473, pl. XLV, figs. 3a, b.

Distinguishable from other species in that its basals are in a depression in calyx base, calyx expands abruptly into a broad bowl shape. RR project below BB. Full width of calyx nearly reached at top of RR. The three anterior rays each carry two arms, and the two posterior rays each carry four arms, making 14 to the species. Specimens figured by Wachsmuth and Springer are small immature forms. Adult forms are as large or larger than *A. immaturus*.

Types. — Springer Collection, United States National Museum. University of Iowa, Topotypes 2117, 2118.

AOROCRINUS RADIATUS (Wachsmuth and Springer)
Plate XV, figure 18

Dorycrinus radiatus WACHSMUTH and SPRINGER, *1890*, Illinois Geol. Survey, vol. VIII, p. 176, pl. 17, figs. 5, 5a. — S. A. MILLER, *1890*, N. Amer. Geol. and Paleontology, p. 240.

Aorocrinus radiatus WACHSMUTH and SPRINGER, *1897*, Cri-

noidea Camerata, Mem. Mus. Comp. Zool. Harvard Univ., vol. 21, p. 472, pl. XLV, fig. 1.

A large species when mature, calyx rapidly expanding, greatest width at arm bases. BB projected into pronounced rim. Arms flaring outward at junction with calyx, plates marked with sharp radiating ridges that become accentuated with mature specimens. Arms 12, 13, or 14, posterior rays normally carrying three arms. X opening from a high pyramid culminating in very small irregular plates, highly eccentric.

Types. — Springer Collection, United States National Museum. University of Iowa, Topotype 2119.

Genus MEGISTOCRINUS Owen and Shumard

MEGISTOCRINUS NOBILIS Wachsmuth and Springer
Plate XVI, figure 1

Megistocrinus nobilis WACHSMUTH and SPRINGER, *1890*, Illinois Geol. Survey, vol. 8, p. 169, pl. 16, figs. 6, 7. — S. A. MILLER, *1890*, N. Amer. Geol. and Paleontology, p. 260. — WACHSMUTH and SPRINGER, *1897*, Mem. Mus. Comp. Zool. Harvard Univ., vol. 21, p. 537, pl. 47, figs. 6, 7, 8a, 8b, pl. 51, fig. 8.

A large species of *Megistocrinus*, distinguished from *M. parvus* with difficulty in immature specimens. *M. nobilis* has a calyx that expands much more rapidly than that of *M. parvus*. Its arms branch closer to the calyx, and interdistichal plates are carried in the calyx. Its plates are smooth while those of *M. parvus* tend to be slightly raised. There are far more interbrachial plates in the calyx of *M. nobilis*.

Types. — United States National Museum, Springer Collection. University of Iowa, Topotype 2120.

MEGISTOCRINUS PARVUS Wachsmuth and Springer
Plate XVII, figure 2

Megistocrinus parvus WACHSMUTH and SPRINGER, *1890*, Illinois Geol. Survey, vol. 8, p. 171, pl. XV, fig. 7.

Pericchocrinus whitei, *1897*, Crinoidea Camerata, Mem. Mus. Comp. Zool. Harvard Univ., vol. 21, p. 530, pl. LI, figs. 8, 10.

This transitional form can best be referred to the genus *Megistocrinus*, although it exhibits some of the characteristics of the genus *Pericchocrinus*. The calyx of all specimens in our possession is defin-

itely typical of the genus *Megistocrinus*, and the thin plates of a typical *Periechocrinus* are not present. The arms are given off from the calyx from contiguous plates as in *Megistocrinus*. The species is definitely not a young immature form of *M. nobilis*. It is easily separable from *M. nobilis* in that the plates of *M. parvus* show a considerable tendency to be nodose. It is easily separable from *P. whitei* of the Burlington with which it has often been compared, in that *P. whitei* has the typical bell shaped thin plated calyx of the genus *Periechocrinus*. The Burlington form has two or three IIBr incorporated in the calyx, while *M. parvus* has only one.

Types. — United States National Museum, Springer Collection. University of Iowa, Topotype 2121.

Family ACTINOCRINIDAE (Roemer)

Genus CACTOCRINUS Wachsmuth and Springer

CACTOCRINUS ORNATISSIMUS (Wachsmuth and Springer)
Plate XVI, figure 5

Actinocrinus ornatissimus WACHSMUTH and SPRINGER, *1890*, Illinois State Geol. Survey, vol. 8, p. 163, pl. XVI, fig. 9. — S. A. MILLER, *1890*, N. Amer. Geol. and Paleontology, p. 219.

Cactocrinus ornatissimus WACHSMUTH and SPRINGER, *1897*, Crinoidea Camerata, Mem. Mus. Comp. Zool. Harvard Univ., vol. 21, p. 621, pl. LVII, fig. 3.

Cactocrinus ornatissimus has characteristics sufficiently diagnostic to prevent it from being confused with other species. Its peculiar discontinuous plate markings readily distinguish it from all other forms. The calyx expands very rapidly, the ratio between calyx length and arm length being 1 to 6. In none of the other LeGrand species is the ratio this great. The calyx is always light in color. The number of arms varies from 28 to 30.

Types. — United States National Museum, Springer Collection. University of Iowa, Topotype 2122, 2123.

CACTOCRINUS NODOBRACHIATUS (Wachsmuth and Springer)
Plate XVI, figure 2

Actinocrinus nodobrachiatus WACHSMUTH and SPRINGER, *1890*, Illinois Geol. Survey, vol. 8, p. 165, pl. XV, fig. 5, pl. XVI, fig. 10. — S. A. MILLER, *1890*, N. Amer. Geol. and Paleontology, p. 219.

Cactocrinus nodobrachiatus WACHSMUTH and SPRINGER,

1897, Crinoidea Camerata, Mem. Mus. Comp. Zool. Harvard Univ., vol. 21, p. 622, pl. LVII, figs. 1, 2.

Cactocrinus nodobrachiatus as originally described and figured is typical of a species that occurs abundantly in the LeGrand fauna. The later illustrations used by Wachsmuth and Springer (17, pl. LVII, figs 1, 2) in Crinoidea Camerata are decidedly non-typical of the species. The difficulty probably lies in the illustration of the calyx because arms appear to be those of *C. nodobrachiatus*.

Calyx definitely conical, not rounded and bowl shaped, expanding regularly up to arm bases. Average height 15 mm., width at arm bases 23 mm. BB large, expand into rim, forming a much more definite portion of calyx than in other LeGrand species of *Cactocrinus*. Plates highly nodose, feebly sculptured, sutures deep. Tegmen plates larger than other LeGrand species of *Cactocrinus*, carrying sharp acuminate spines. X tube slender, reaching to arm tips, plates spinose. Arm number variable from 28 to 30. Every possible gradation seems to be present. Occasionally spines are carried on alternate brachials on the arms. This is not a diagnostic feature as nearly all species of *Cactocrinus* carry them occasionally.

Types. — United States National Museum, Springer Collection. University of Iowa, Topotypes 2124, 2125, 2126.

CACTOCRINUS ARNOLDI (Wachsmuth and Springer)
Plate XVI, figures 3, 4

Actinocrinus arnoldi WACHSMUTH and SPRINGER, *1890*, Illinois State Geol. Survey, vol. 8, p. 168, pl. XVII, fig. 10, — S. A. MILLER, *1890*, N. Amer. Geol. and Paleontology, p. 217.

Cactocrinus arnoldi WACHSMUTH and SPRINGER, *1897*, Crinoidea Camerata, Mem. Mus. of Comp. Zool. Harvard Univ., vol. 21, p. 624, pl. LVII, figs. 4a, 4b.

The original illustration of *Cactocrinus arnoldi* represents a very mature specimen.

Largest species of *Cactocrinus* in fauna often measuring as much as 80 mm. from base to arm tips. Calyx rapidly expanding, bowl-shaped, normally 20 mm. in height, width 30 mm. at arm bases. BB smaller in proportion to calyx than in *C. nodobrachiatus*. Plates stellate with both primary and secondary ridges. Inter-plate sutures not as depressed as in *C. nodobrachiatus*. IBr only slightly smaller than RR. iBr_1 as large as IBr. Arms 22 to 30. Ventral disk of smaller plates than in *C. nodobrachiatus* or *C. ornatissimus*.

Tube long, slender, reaching to arm tips, not markedly spinose.

Observations. — Easily distinguishable from *C. nodobrachiatus* because the calyx of *C. arnoldi* expands more rapidly. BB smaller, sutures not depressed, marked secondary stellate ridges on plates, and the disk is not spinose.

Types. — Collection of Hon. Delos Arnold, Pasadena, California. University of Iowa, Topotypes 2127, 2128, 2129.

Family PLATYCRINIDAE Roemer

Genus PLATYCRINUS Miller

PLATYCRINUS SYMMETRICUS Wachsmuth and Springer
Plate XVI, figures 6, 7, 8

Platycrinus symmetricus WACHSMUTH and SPRINGER, *1889*, Illinois Geol. Survey, vol. 8, p. 186, pl. 15, fig. 8.

P. planus WACHSMUTH and SPRINGER, *1889*, Illinois Geol. Survey, vol. 8, p. 188, pl. XVI, fig. 8.

P. symmetricus WACHSMUTH and SPRINGER, *1897*, Crinoidea Camerata, Mem. Mus. Comp. Zool. Harvard Univ., vol. XXI, p. 655, pl. III, fig. 16, pl. LXIX, figs. 1a, b, c.

P. agassizi WACHSMUTH and SPRINGER, *1897*, Crinoidea Camerata, Mem. Mus. Comp. Zool. of Harvard Univ., vol. XXI, p. 669, pl. LXIX, fig. 4.

The confusion that has arisen over the interpretation of the species of *Platycrinus* that occur in the LeGrand fauna comes mainly from the wide variety of forms exhibited during the relative stages of maturity of the individuals. With several hundred specimens available for study the intergradations of the various forms become immediately apparent. Immature specimens have a conical shape while the more mature forms exhibit a higher calyx with straight calyx walls. We have sectioned a large number of specimens, and in all the projecting basal rim is apparently cut by the basal sutures. The very delicate slender arm structure distinguishes this species readily from all other forms.

Types. — United States National Museum, Springer Collection. University of Iowa, Topotypes 2130, 2131, 2132, 2133.

PLATYCRINUS PENDENS Springer
Plate XIX, figure 1, Plate XVII, figure 3

Platycrinus pendens SPRINGER, *1926*, Proc. United States Nat. Mus., vol. 67, art. 9, no. 2581, p. 38, pl. 9, figs. 5, 5a.

A new species was erected for specimens of *Platycrinus* in the LeGrand fauna in which the arms curve outward over the calyx. Since the original description three more specimens have been found showing excellently the pendent arms. The calyx structure appears to be almost identical with that of *P. symmetricus*. Whether the pendent arm structure should be taken as the diagnostic characteristic of a species is open to question. If the arms are habitually in a pendent position during the life of the individual the characteristic should certainly be considered of specific value. Two excellent specimens are figured here.

Types. — United States National Museum, Springer Collection. University of Iowa, Topotypes 2134, 2135.

Family HEXACRINIDAE Wachsmuth and Springer

Genus DICHOCRINUS Münster

DICHOCRINUS INORNATUS Wachsmuth and Springer
Plate XVI, figure 9

Dichocrinus inornatus WACHSMUTH and SPRINGER, *1889*, Illinois Geol. Survey, vol. 8, p. 190, pl. 16, figs. 1, 2. — *1897*, Crinoidea Camerata, Mem. Mus. Comp. Zool. Harvard Univ., vol. XXI, p. 770, pl. LXXV, fig. 6.

One of the most commonly occurring forms in the fauna. Closely related to *D. hammondi* n. sp., but differing in that it has only 2 arms to the ray while *D. hammondi* has 3 to each ray. Both species are dark in color. Its closest other relative is *D. ovatus* of the lower Burlington limestone, which is larger and has a more globose ovate calyx.

Types. — United States National Museum, Springer Collection. University of Iowa, Topotypes 2136, 2137, 2138, 2139.

DICHOCRINUS DELICATUS Wachsmuth and Springer
Plate XVII, figure 4

Dichocrinus delicatus WACHSMUTH and SPRINGER, *1897*, Crinoidea Camerata, Mem. Mus. Comp. Zool. Harvard Univ., vol. XXI, p. 766, pl. LXXVII, fig. 13.

A very small, rarely occurring form, found usually in the *Pachylocrinus* zone at the base of the section. Always white in color. *D. delicatus* is closely related to *D. multibrachiatus* which occurs so prolifically in the Gilmore City formation. It differs in that it is smaller and the BB expand much more abruptly.

Types. — United States National Museum, Springer Collection. University of Iowa, Topotype 2140.

DICHOCRINUS CINCTUS Miller and Gurley

Plate XIX, figure 2

Dichocrinus cinctus MILLER and GURLEY, *1888*, 16th Annual Report of Geol. and Nat. Hist. Indiana, p. 342, pl. LV, figs. 10, 11, 12. — WACHSMUTH and SPRINGER, *1897*, Crinoidea Camerata, Mem. Mus. Comp. Zool. Harvard Univ., vol. XXI, p. 764, pl. LXXV, fig. 5, pl. LXXVII, figs. 4a, b, c.

One of the most distinctive species in the LeGrand fauna. Characterized by its slender striated calyx and its long, very slender arms with exceptionally short pinnules. Recent work in the area has uncovered great numbers of this species. It is in the line of ancestry to *D. bozemanensis*, which occurs abundantly in the Gilmore City fauna and also in the Madison limestone of the west.

Types. — Walker Museum, University of Chicago. Gurley Collection. University of Iowa, Topotypes 2168, 2169.

DICHOCRINUS HAMMONDI n. sp.

Plate XVI, figure 10

Represented by three specimens, all dark colored like *D. inornatus* to which they are closely related. Height of holotype 30 mm. Calyx 7 mm., arms 23 mm. BB two, expanding rapidly. RR 5, height 4.5 mm., almost as wide at base as at top. X as large as RR. Arms occupy constricted upper surface of RR. Color dark brown, plates smooth, sutures not depressed. Arms three to the ray, making 15 to the species. IBr two, united by syzygy. IIBr two, followed by biserial Br. Pinnules long, stout. Column round as in *D. inornatus*. This species is identical with *D. inornatus* except for its arm formula. Three specimens have been found on one small slab in close association with each other, and all show the extra arms. Two of the specimens are damaged slightly so that it is difficult to determine the arm formula on all of the rays. One ray on one of them definitely carries only two arms.

This species is named in honor of Mr. Louis Hammond of LeGrand, Iowa.

Types. — University of Iowa, Holotype 2141, Paratypes 2142, 2143.

Family ACROCRINIDAE Wachsmuth and Springer

Genus ACROCRINUS Yandell

ACROCRINUS PRIMITIVUS n. sp.
Plate XVII, figures 5, 6

This single specimen taken from the *Pachylocrinus* zone in the LeGrand beds throws a great deal of additional light on the evolution of the genus *Acrocrinus* from *Dichocrinus*. There is little question left as to its origin from *Dichocrinus* but the exact manner in which the extra plates are introduced into the calyx is not too well understood. The specimen carries a single row of irregular plates between the BB and RR. *A. intermedius* from the lower Chester of Illinois, heretofore considered as the most primitive species of the genus, carries two rows of supplementary plates between the RR and BB. *A. primitivus* n. sp. can be seen to lie midway between *Dichocrinus* and *A. intermedius* so far as its evolutionary position is concerned.

BB two as in *Dichocrinus* forming a conical base rising 2 mm. in height. Supplementary plates between BB and RR 6, variable in shape, much higher than wide, much larger and higher than RR. Supplementary X hexagonal, height 4 mm., width 2 mm. Right posterior supplementary plate quadrangular, height 3 mm., width 2 mm. Right anterior supplementary plate hexagonal, height 4 mm., width 3 mm.; anterior supplementary plate hexagonal, height 4 mm., width 2 mm. Right posterior supplementary plate, height 3 mm., width 2 mm. RR 5, variable in size, wider than high. Right posterior heptagonal, small. Right anterior hexagonal, largest, width 2 mm., height 1.5 mm. Anterior heptagonal. Left anterior octagonal, much broader than high. Left posterior heptagonal, very small. X small, slightly protruding, situated between and slightly above the posterior RR. Arms 10, biserial. IBr 2, united in syzygy as in *Dichocrinus*. Pinnules small, closely packed.
Types. — University of Iowa, Holotype 2144.

Order FLEXIBILIA Zittel
Suborder TAXOCRINOIDEA Wachsmuth and Springer
Family TAXOCRINIDAE Wachsmuth emend. Springer

Genus TAXOCRINUS Phillips

TAXOCRINUS INTERMEDIUS Wachsmuth and Springer
Plate XVII, figure 9 and Plate XVIII, figure 1

Taxocrinus intermedius WACHSMUTH and SPRINGER, *1888*,

Proc. Acad. Nat. Sci. Philadelphia, p. 344, pl. 18, figs. 10a to e. — *1889*, Illinois Geol. Surv., vol. VIII, p. 199, pl. 15, fig. 11. — ZITTEL, *1895*, Grundzuge Palaeontologie, p. 138, fig. 272. — ZITTEL-EASTMAN, *1896*, Textbook of Paleontology, p. 164, fig. 272, (2nd Ed.) *1913*, p. 178, fig. 276, and p. 206, fig. 306. — WACHSMUTH and SPRINGER, *1897*, Crinoidea Camerata, Mem. Mus. Comp. Zool. Harvard Univ., vol. XX, pl. 3, fig. 11, pl. 8, figs. 5a, b. — BATHER, *1898*, Geol. Magazine, Dec. IV, V, p. 524. — LANKESTER, *1900*, Treatise on Zoology, pt. 3, p. 126, fig. 37.

This large, commonly occurring species of *Taxocrinus* has been used many times for illustration of various parts of the anatomy of flexible crinoids. It differs from others in the LeGrand fauna in its large size and the relatively wide spreading interbrachial areas.

Types. — United States National Museum, Springer Collection. University of Iowa, Topotype 2145.

TAXOCRINUS HOLLANDI n. sp.

Plate XIX, figure 3

Known from two specimens, one fairly complete. Characterized by its small size, its acutely conical calyx, its exceptionally large IBB and BB, and its relatively small slender arms. Calyx height to tops of RR 3.5 mm. Arms approximately 16 mm. in length. IBB low but higher than average *Taxocrinus*. BB 5, height equals width, RR 5, half the size of the BB, supporting small free arm plates. Posterior BB truncated, supporting X plate in center. Single X series slightly smaller than arm plates. Arms slender, dichotomous, diverging slightly. IBr 3, IIBr variable, from 9 to 15, iBr not present, areas covered with leathery skin studded with small calcareous plates. Stem expanding rapidly proximally, columnals very thin.

Named in honor of Mr. Magnes Holland of LeGrand, Iowa.

Types. — University of Iowa, Holotype 2146.

Genus EUTAXOCRINUS Springer

EUTAXOCRINUS FLETCHERI (Worthen)

Plate XVII, figures 7, 8

Taxocrinus fletcheri WORTHEN, *1882*, Bull. 1, Illinois State Mus., p. 31. — *1883*, Geol. Survey Illinois VII, p. 308, pl. 30, fig. 2. — WACHSMUTH and SPRINGER, *1886*, Revision of Paleo-

crinoidea, pt. 3, p. 144. — *1889*, Illinois Geol. Survey, vol. VIII, p. 197, pl. 15, figs. 6, 9.

Eutaxocrinus fletcheri SPRINGER, *1920*, The Crinoidea Flexibilia, Smithsonian Inst., Publication 2501, p. 371, pl. L, figs. 11-19.

A smaller and more commonly occurring form than *T. intermedius*. Found only in the *Cactocrinus* zone. Characterized by its closely abutting arms. One of the last occurring species of this genus.

Types. — Worthen Collection. Figured specimens, United States National Museum, Springer Collection. University of Iowa, Topotypes 2147, 2148.

Order INADUNATA Wachsmuth and Springer
Suborder FISTULATA Wachsmuth and Springer
Family GLOSSOCRINIDAE Goldring

Genus GONIOCRINUS Miller and Gurley

GONIOCRINUS SCULPTILIS Miller and Gurley
Plate XIX, figure 4

Goniocrinus sculptilis, MILLER and GURLEY, *1888*, 16th Annual Rep. Indiana Geol. and Nat. Hist., p. 352, pl. 6, figs. 2, 3, 4, 5.

This genus is represented by only two species both occurring in the Kinderhook of Iowa. It was placed in the family Glossocrinidae by Laudon (6) because of the strong row of median plates running up the anal sac which is certainly of more significance than the small remnant radianal plate which was inherited from the Cyathocrinidae. A small quadrangular radianal plate lies in the calyx in the Gilmore City species but does not appear in the LeGrand forms. The arms bear rammules instead of pinnules. The column carries cirri throughout its length. Plates angular, depressed at corners. The LeGrand form is separated from the Gilmore City species easily in that it is smaller and has very angular plates with deeply depressed sutures.

Types. — Gurley Collection, Walker Museum, Chicago University. University of Iowa, Topotype 2149.

Family POTERIOCRINIDAE Roemer (em. Wachsmuth and Springer)

Genus PACHYLOCRINUS Wachsmuth and Springer

PACHYLOCRINUS SPARTARIUS (Miller and Gurley)
Plate XIX, figure 5, Plate XVIII, figure 2

Poteriocrinus spartarius MILLER and GURLEY, *1888*, Indiana

Geol. and Nat. Hist., 16th Ann. Rep., p. 355, pl. VII, fig. 1.

P. genista MILLER and GURLEY, *1888*, Indiana Geol. and Nat. Hist., 16th Ann. Rep., p. 355, pl. VII, fig. 3.

P. scopae MILLER and GURLEY, *1888*, Indiana Geol. and Nat. Hist., 16th Ann. Rep., p. 355, pl. VII, fig. 2. — Bull. 5. Illinois State Mus. of Nat. Hist., p. 33, pl. III, figs. 1, 2.

A rather delicate slender species of *Pachylocrinus*, exhibiting all of the typical characteristics of that genus. The confusion that has arisen over the interpretation of this species lies in the fact that when first studied there were not enough specimens available to show all of the variations within the species. *P. scopae* and *P. genista* were erected by Miller and Gurley (8, p. 256, 257) entirely on the basis of rather insignificant differences in arm structure. More or less complete intergradations between the various species set up by Miller and Gurley are now in our possession. Since all of them occur in the *Pachylocrinus* zone it is likely that they represent one species.

Revised description. — IBB 5, small, 1 mm., in height, BB 5, height 2.5 mm., width 2 mm. RR 5, much wider than high, 3 mm. width. Calyx evenly conical, 6 mm. wide at top RR. IBr 2, often fused by syzygy. IIBr varying between 7-10. Arms, slender, dichotomous, branching usually 3 times, Br slightly cuneiform. Pinnules relatively coarse. RA as large as anal, both smaller than posterior BB, sac reaching almost to arm tips, opening not observed as yet. Stem round, carrying cirri throughout its length.

Types. — Gurley Collection, Walker Museum, Chicago University. University of Iowa, Topotypes 2150, 2151.

PACHYLOCRINUS RAYMONDI n. sp.

Plate XVIII, figure 4

Represented by four specimens, all somewhat damaged. Calyx broad, very low, height 1½ mm., width 7 mm. Arm length 18 mm. IBB small, protruding slightly beyond column, BB laterally directed, much broader at tops than at base. RR low, very wide, 3 mm., in width. IBr 1, much broader than high. Arms exhibiting perfect unilateral heterotomy. IIBr 5 to 7. IIIBr 6 to 8, branching normally 3 times, little tendency for cuneiform Br. Pinnules short, slender. X structure not available for study. Column round, characterized by whorls of long slender cirri given off on alternate columnals. These cirri apparently envelop the calyx and arms,

reaching at a maximum slightly beyond the arms. The longest available measures 52 mm. in length. Many of the species of *Pachylocrinus* of the early lower Carboniferous carried cirri throughout the entire length of the column. *P. fimbria* and *P. cirrifer* (6) of the Gilmore City formation are excellent examples. The unilateral heterotomous arms and broad calyx of *P. raymondi* are transitional toward *Zeacrinus*. Whether this form should be classified as an early form of *Zeacrinus* or a progressive form of *Pachylocrinus* is questionable. Because the arms are not closely abutting as is typical of *Zeacrinus* the species is referred to the genus *Pachylocrinus*.

Occurence. — This species has been found only in the lower portion of the *Pachylocrinus* zone at LeGrand. All four specimens were collected in the Timber Creek quarry, two miles west of LeGrand, Iowa.

Named in honor of Mr. Raymond Beane of LeGrand, Iowa.

Types. — University of Iowa, Holotype 2152.

PACHYLOCRINUS LEGRANDENSIS (Miller and Gurley)
Plate XVIII, figure 3

Poteriocrinus legrandensis MILLER and GURLEY, *1888*, 16th Annual Report, Indiana Geol. and Nat. Hist., p. 357, pl. 7, figs. 4, 5, 6.

Scaphiocrinus elegantulus WACHSMUTH and SPRINGER, *1890*, Illinois Geol. Survey, vol. VIII, p. 195, pl. XVII, fig. 13.

A very slender delicate species of *Pachylocrinus* characterized by a small low calyx, slender arms, with long cuneiform brachials, branching only twice. Pinnules exceptionally coarse for the size of the arms. Anal area relatively wide. Easily separable from *P. spartarius* in that it has long cuneiform brachials, coarse pinnules, shallower calyx, and its arms branch only once.

Types. — Cotypes, Gurley Collection, Walker Museum, University of Chicago. University of Iowa, Topotypes 2153, 2154.

PACHYLOCRINUS GLOBOSUS (Wachsmuth and Springer)
Plate XVII, figure 10

Scaphiocrinus globosus WACHSMUTH and SPRINGER, *1890*, Illinois Geol. Survey, vol. VIII, p. 196, pl. XVII, fig. 8.

A relatively rarely occurring species characterized by a rapidly expanding relatively globose calyx with IBB hidden in BB concavity. Calyx sutures depressed, one short angular IBr. BB very

cuneiform. Arms short usually branching only twice. Stem exceptionally small for size of calyx.

Types. — United States National Museum, Springer Collection. University of Iowa, Topotypes 2155, 2156.

Genus ABROTOCRINUS Miller and Gurley

ABROTOCRINUS PARVIGLYPTUS n. sp.

Plate XVII, figures 14, 15, Plate XVIII, figure 5

A bizarre species characterized by its extremely angular cuneiform Br. The incomplete holotype measures 45 mm., from base to broken arm tips. Calyx 4 mm., in height, width at top of RR 9 mm. Calyx, evenly conical, height one-half width, IBB small, only tips enter into calyx wall. BB height equals width 3 mm. in holotype. RR wider than high, width 6 mm. Distal face raised and curved. RA in normal position rising to half height of left posterior RR. X and RA slightly smaller than posterior BB. Calyx plates sharply sculptured, corners depressed. Arms, IBr 1, except in anterior which has 2, higher than wide, with sharp median ridge. IIBr normally eight, sharply cuneiform, carrying an undulating sharp angular median ridge. IIBr normally 16, carrying the same undulating ridge. Pinnules coarse, relatively short. Sac not observed, column pentagonal.

Occurrence. — All specimens have been found on a single slab about 4 feet in diameter from the *Pachylocrinus* zone in the south end of the large south quarry at LeGrand, Iowa.

Types. — University of Iowa, Holotype 2157, Paratype 2158.

Genus ZEACRINUS (Troost) Hall

ZEACRINUS INFREQUENS n. sp.

Plate XVII, figures 11, 12

One of the more primitive members of the genus *Zeacrinus*, represented by four specimens. A small species 24 mm., from base to arm tips. Calyx, 4 mm. high, 5.5 mm. in width. IBB small forming an inconspicuous portion of calyx, BB 5, slightly smaller than RR. RR 5, slightly broader than high. X and RA slightly smaller than posterior BB. IBr 1, low, broader than high except in anterior, where there are 2. Arms unilaterally heterotomous, transitional between *Pachylocrinus* and *Zeacrinus*, relatively closely abutting, Br short, quadrangular, normally branching four times. Pinnules short, closely packed. Sac not observed. Column round.

Types. — University of Iowa, Holotype 2159, Paratype 2160.

Genus SCYTALOCRINUS Wachsmuth and Springer

SCYTALOCRINUS MACCABEI (Miller and Gurley)

Plate XVII, figure 13, Plate XVIII, figures 6, 7, Plate XIX, figure 6

Poteriocrinus maccabei MILLER and GURLEY, *1894*, Illinois State Museum of Nat. Hist. Bull. 5, p. 34, pl. III, figs. 3 to 6.

Poteriocrinus maccabei var. decrepitus MILLER and GURLEY, *1894*, Illinois State Museum of Nat. Hist. Bull. 5, p. 36, pl. III, figs. 9 to 12.

Poteriocrinus hammondi MILLER and GURLEY, *1894*, Illinois State Museum of Nat. Hist. Bull. 5, p. 35, pl. III, figs. 7, 8.

The difficulties which have arisen over the interpretation of this species of *Scytalocrinus* lie again mainly in the differences exhibited between immature and mature specimens. The IBr reach their full length very early, making them seem overly long in the immature specimens. We have a great number of specimens from the zone in which this species occurs, and as a result can trace the development from very small specimens. *S. hammondi* was probably established mainly because of the fact that the holotype had the arms constricted immediately above the calyx giving the appearance of an entirely different species. The anal area in *S. hammondi* is incorrectly illustrated.

Types. — Gurley Collection, Walker Museum, University of Chicago. University of Iowa, Topotypes 2161, 2162.

Genus DECADOCRINUS Wachsmuth and Springer

DECADOCRINUS BAUMGARDNERI n. sp.

Plate XVIII, figure 10

This species is represented by a single specimen. Its striking bizarre structure coupled with its excellent preservation make its identity as a new species unquestionable. Length of specimen from base of calyx to arm tips 45 mm. The total length of the specimen during life was considerably more since one of the curved arms alone measures 55 mm. Calyx, bowl shaped, expanding rapidly, height 4 mm., width 8 mm. IBB small, hidden beneath the column, except for their tips. BB large, with high globose central node. RR as large as BB, slightly less nodose. RA smaller than X, in typical position in contact with right and left posterior BB beneath, X and right posterior RR laterally, and right primary tube plate above. X slightly smaller than RR, in contact with RA and left posterior

BB beneath, right primary tube plate and left posterior RR laterally, and middle primary tube plate above. Plates of the X series also nodose. Arms, peculiar, thick, branching once on the IBr_2, characterized by extremely cuneiform nodose Br bearing short thick-set ramules. Column, round, rather heavy, consisting of alternately expanded columnals. Lumen small. Only a few segments in the upper portion of the column are preserved. Anal sac not observed. This species is sharply distinguishable from all other species of *Decadocrinus* because of its peculiar nodose arm structure and its nodose calyx.

Named in honor of Mr. B. K. Baumgardner of LeGrand, Iowa.

Types. — University of Iowa, Holotype 2163.

Genus GILMOCRINUS Laudon

GILMOCRINUS O'NEALI n. sp.

Plate XIX, figure 7

The genus *Gilmocrinus* was erected in 1933 by Laudon (6) to care for members of the Poteriocrinidae having less than the 10 arms normally carried by *Decadocrinus*. *Gilmocrinus iowensis*, the genotype, carried between 5 and 7 arms. *G. o'neali* marks the third occurrence of this genus in North America. The species is known from two partially complete specimens. Calyx, conical, height 8 mm., width 10 mm., at tops of RR. Arms exceptionally long and slender; complete length not obtainable. IBB large making a conspicuous portion of calyx, RR large, height 3 mm., width 3 mm., RR 5, wider than high, free arms above RR. X and RA in normal position. Arms apparently 5, exceptionally long and slender. Br slightly cuneiform in upper portion. Br much longer in lower portion of arms. Pinnules exceptionally short and small. The arms and portions of the tube are broken from the holotype and scattered around the slab. One portion of an arm is 112 mm., in length and obviously represents the upper portion of the arm. The arms may have reached a length of 150 mm. Tube, rapidly tapering, consisting of small hexagonal plates, length unknown. Column round, typical of the family.

Named in honor of Mr. Corwin O'Neal of LeGrand, Iowa.

Occurrence. — From the soft dolomitic ledges of the *Pachylocrinus* zone at LeGrand.

Types. — University of Iowa, Holotype 2164.

Subfamily GRAPHIOCRINIDAE Bather

Genus GRAPHIOCRINUS DeKoninck

GRAPHIOCRINUS LONGICIRRIFER Wachsmuth and Springer
Plate XIX, figure 8, Plate XVIII, figures 8, 9

Graphiocrinus longicirrifer WACHSMUTH and SPRINGER, *1890*, Illinois State Geol. Survey, vol. 8, p. 193, pl. XV, fig. 12, pl. XVII, fig. 14.

The structure of *Graphiocrinus* is identical with that of *Decadocrinus* or *Scytalocrinus* except that it lacks the RA plate. The tube rises directly from a single X plate in line with the RR. *G. longicirrifer* is one of the most unusual of the LeGrand crinoids. The X tube occasionally rises as much as an inch above the long slender arms. The IBB are small, almost hidden by the column. The calyx expands rapidly. The arms are long and slender characterized by very cuneiform Br with short coarse pinnules. The column is characterized by whorls of cirri throughout its length.

Types. — United States National Museum, Springer Collection. University of Iowa, Topotypes 2165, 2166.

Genus PHILOCRINUS Koninck

PHILOCRINUS NOTATUS (Miller and Gurley)
Plate XVIII, figure 11

Scaphiocrinus notatus MILLER and GURLEY, *1896*, Bull. 9, Illinois State Mus. of Nat. Hist., p. 34, pl. II, figs. 26, 27.

The genus *Philocrinus* was defined by DeKoninck (2) in 1863 and *Philocrinus cometa* designated as the genotype. The genus and species was defined from a single specimen from the middle portion of the *Productus* limestone (Upper Carboniferous) of India. The genotype has since been lost. As originally defined the genus was incorrect in that the anal structure was not observed or described. The characteristic arm structure as shown by the illustration, however, make its identity certain.

The genus was emended and correctly defined by Waagen (18) in 1887. Two more incomplete specimens of *Philocrinus cometa* were discovered in the same area in which the genotype was found. In these specimens a single anal plate is shown in the calyx, radial in position, lying on the truncated upper surface of the posterior BB.

The small IBB, the single X plate radial in position, and the rapidly expanding calyx show *Philocrinus* to belong definitely with

the Graphiocrinidae. The type of arm structure both as to number and point of origin and the extremely cuneiform brachials are identical with those of the genus *Ulrichicrinus* as defined by Springer (12) in 1926. *Ulrichicrinus* however definitely shows both anal and radianal plates. They are irregular for the Poteriocrinidae in that the RA is far larger, with the X barely in contact with the posterior BB. This type of structure is also shown in *Woodocrinus*.

P. notatus is defined as follows: Calyx rapidly expanding, IBB very small, BB half size of RR; posterior considerably higher than others. RR width twice height. X small hexagonal, resting on truncated upper surface of posterior BB, lower portion in contact laterally with RR. IBr large, axillary carrying a variable number of arms. Arms relatively short and stout, twelve or thirteen in number; the two posterior rays carrying three each with the anterior ray occasionally carrying three. When arms branch they do so on IIBr number one. Br. exceptionally cuneiform. Pinnules short.

Types. — Gurley Collection, Walker Museum, University of Chicago. University of Iowa, Topotype 2167.

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EXPLANATION OF PLATE XV

All specimens came from the Lower Mississippian Hampton formation near LeGrand, Iowa. All figures are X 1.

Fig. 1. *Rhodocrinus watersianus* Wachsmuth and Springer . 241
Lateral view of holotype, after Wachsmuth and Springer.

Figs. 2, 3. *Rhodocrinus wortheni* Hall 243
Right anterior and left posterior views, respectively, of a mature specimen (Univ. Iowa 2109).

Figs. 4, 5. *Rhodocrinus nanus* Meek and Worthen 240
Anterior and posterior views, respectively, of two specimens, after Wachsmuth and Springer.

Figs. 6, 10, 11. *Rhodocrinus nanus glyptoformis* Laudon and Beane, n. var. 241
Fig. 6 — one of syntypes of *R. nanus* after Wachsmuth and Springer. Figs. 10, 11 — right anterior and posterior views, respectively, of a syntype (Univ. Iowa 2102).

Fig. 7. *Rhodocrinus kirbyi* Wachsmuth and Springer . . 240
After Wachsmuth and Springer.

Figs. 8, 9. *Rhodocrinus octadactylus* Laudon and Beane, n. sp. . 242
Left posterior view of paratype and anterior view of holotype (Univ. Iowa 2106 and 2105 respectively).

Fig. 12. *Rhodocrinus douglassi haploformis*, Laudon and Beane, n. var. 242
Posterior view of holotype (Univ. Iowa 2107).

Figs. 13, 14. *Batocrinus macbridei* Wachsmuth and Springer . . 244
Both figures are after Wachsmuth and Springer.

Fig. 15. *Batocrinus poculum* Miller and Gurley . . . 244
After Wachsmuth and Springer.

Fig. 16. *Aorocrinus parvibasis* (Wachsmuth and Springer) . 245
After Wachsmuth and Springer.

Fig. 17. *Aorocrinus immaturus* (Wachsmuth and Springer) . 244
After Wachsmuth and Springer.

Fig. 18. *Aorocrinus radiatus* (Wachsmuth and Springer) . . 245
After Wachsmuth and Springer.

Fig. 19. *Cactocrinus arnoldi* (Wachsmuth and Springer) . . 248
Right posterior view of relatively light colored specimen from the *Spiriferina* zone at LeGrand (Univ. Iowa 2127).


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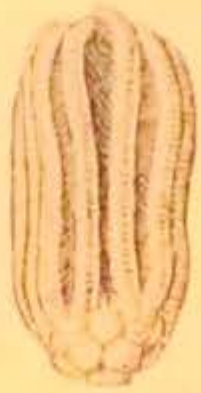
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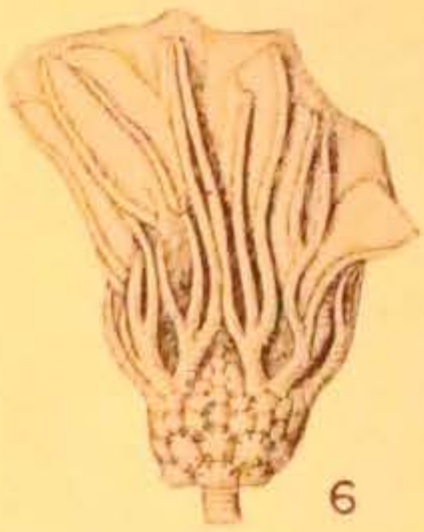
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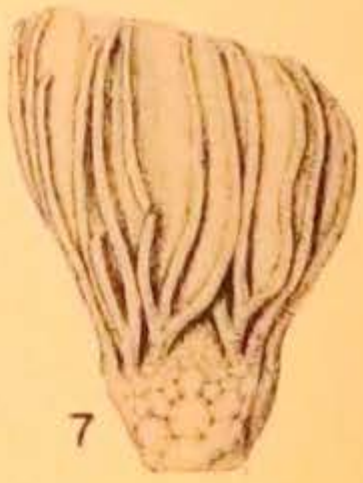
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EXPLANATION OF PLATE XVI

All specimens came from the Lower Mississippian Hampton formation near LeGrand, Iowa. All figures are X 1.

Fig. 1. *Megistocrinus nobilis* Wachsmuth and Springer . . . 246
Posterior view after Wachsmuth and Springer.

Fig. 2. *Cactocrinus nodobrachiatus* (Wachsmuth and Springer) . 247
Anterior view of a syntype after Wachsmuth and Springer.

Figs. 3, 4. *Cactocrinus arnoldi* (Wachsmuth and Springer) . . . 248
Right anterior view of an immature specimen and right posterior view of a large mature specimen (Univ. Iowa 2128 and 2129 respectively).

Fig. 5. *Cactocrinus ornatissimus* (Wachsmuth and Springer) . . 247
Posterior view of the holotype after Wachsmuth and Springer.

Figs. 6-8. *Platycrinus symmetricus* Wachsmuth and Springer . . 249
Fig. 6, after Wachsmuth and Springer, was figured as *P. planus*. Fig. 7, basal view of small specimen; and fig. 8, specimen showing calyx markings (Univ. Iowa 2130 and 2131).

Fig. 9. *Dichocrinus inornatus* Wachsmuth and Springer . . . 250
After Wachsmuth and Springer.

Fig. 10. *Dichocrinus hammondi* Laudon and Beane n. sp. . . . 251
Right anterior view of holotype (Univ. Iowa 2141).

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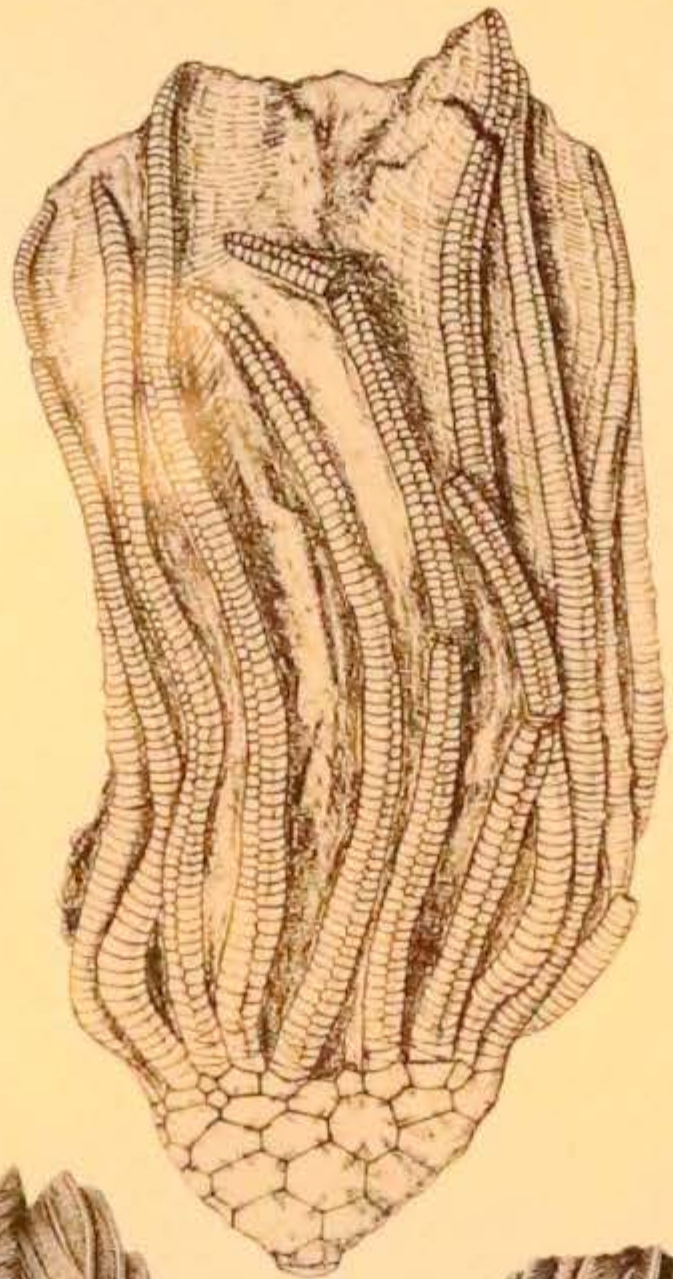

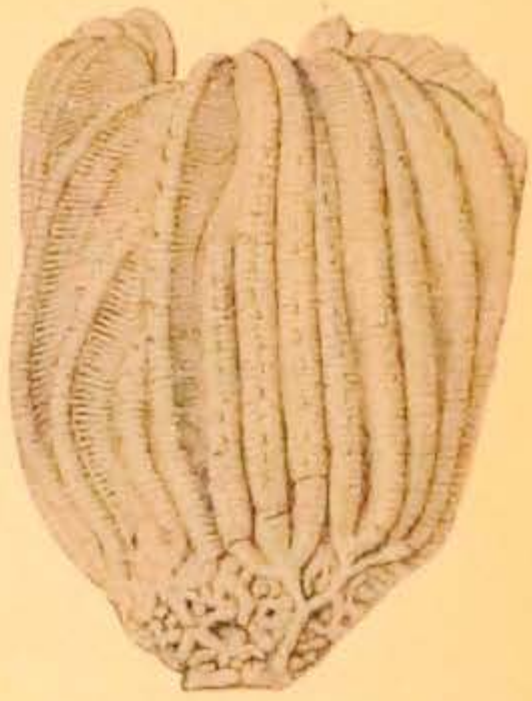

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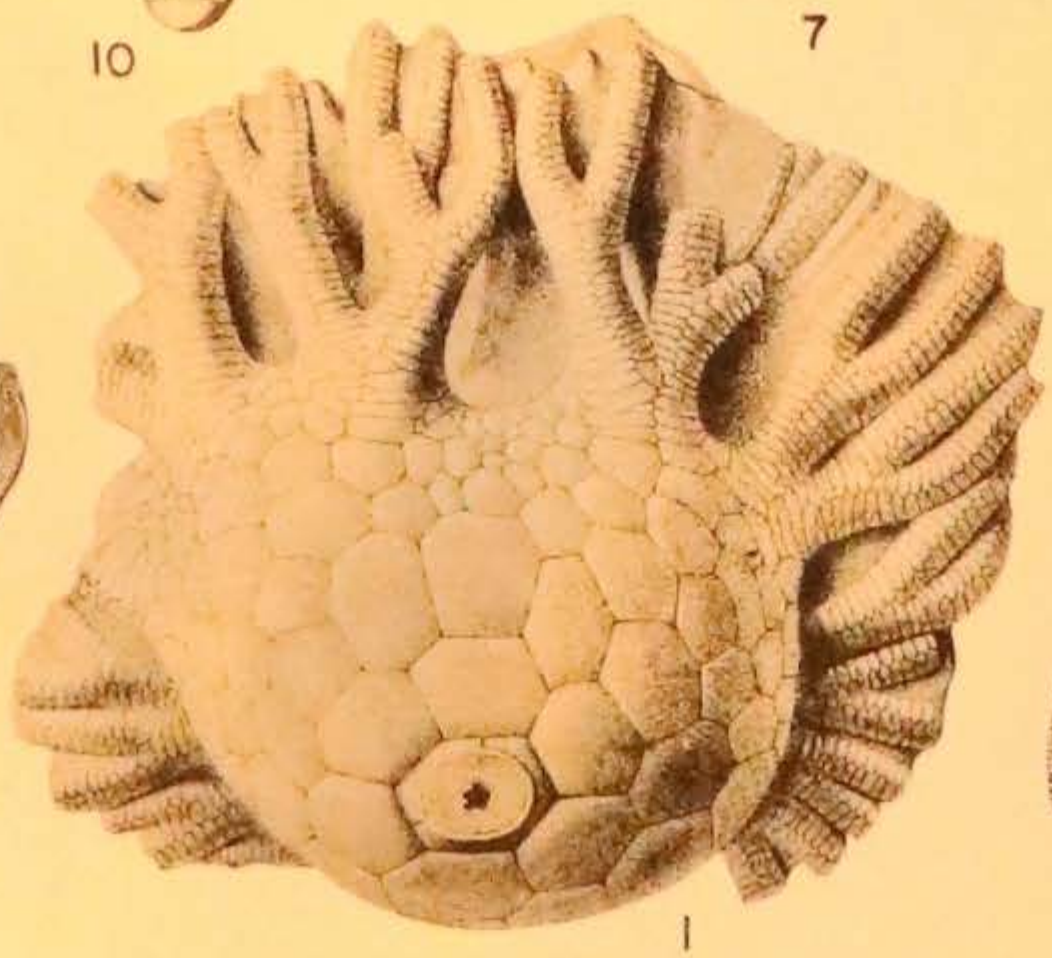

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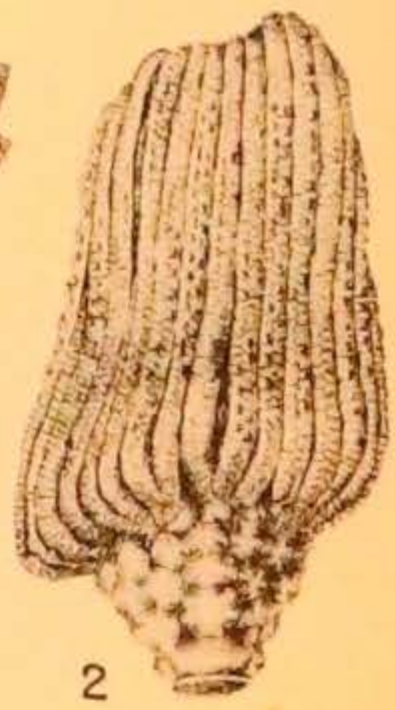

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EXPLANATION OF PLATE XVI

All specimens came from the Lower Mississippian Hampton formation near LeGrand, Iowa. All figures are X 1.

Fig. 1. *Megistocrinus nobilis* Wachsmuth and Springer . . . 246
Posterior view after Wachsmuth and Springer.

Fig. 2. *Cactocrinus nodobrachiatus* (Wachsmuth and Springer) . 247
Anterior view of a syntype after Wachsmuth and Springer.

Figs. 3, 4. *Cactocrinus arnoldi* (Wachsmuth and Springer) . . . 248
Right anterior view of an immature specimen and right posterior view of a large mature specimen (Univ. Iowa 2128 and 2129 respectively).

Fig. 5. *Cactocrinus ornatissimus* (Wachsmuth and Springer) . . 247
Posterior view of the holotype after Wachsmuth and Springer.

Figs. 6-8. *Platycrinus symmetricus* Wachsmuth and Springer . . 249
Fig. 6, after Wachsmuth and Springer, was figured as *P. planus*. Fig. 7, basal view of small specimen; and fig. 8, specimen showing calyx markings (Univ. Iowa 2130 and 2131).

Fig. 9. *Dichocrinus ornatus* Wachsmuth and Springer . . . 250
After Wachsmuth and Springer.

Fig. 10. *Dichocrinus hammondi* Laudon and Beane n. sp. . . . 251
Right anterior view of holotype (Univ. Iowa 2141).

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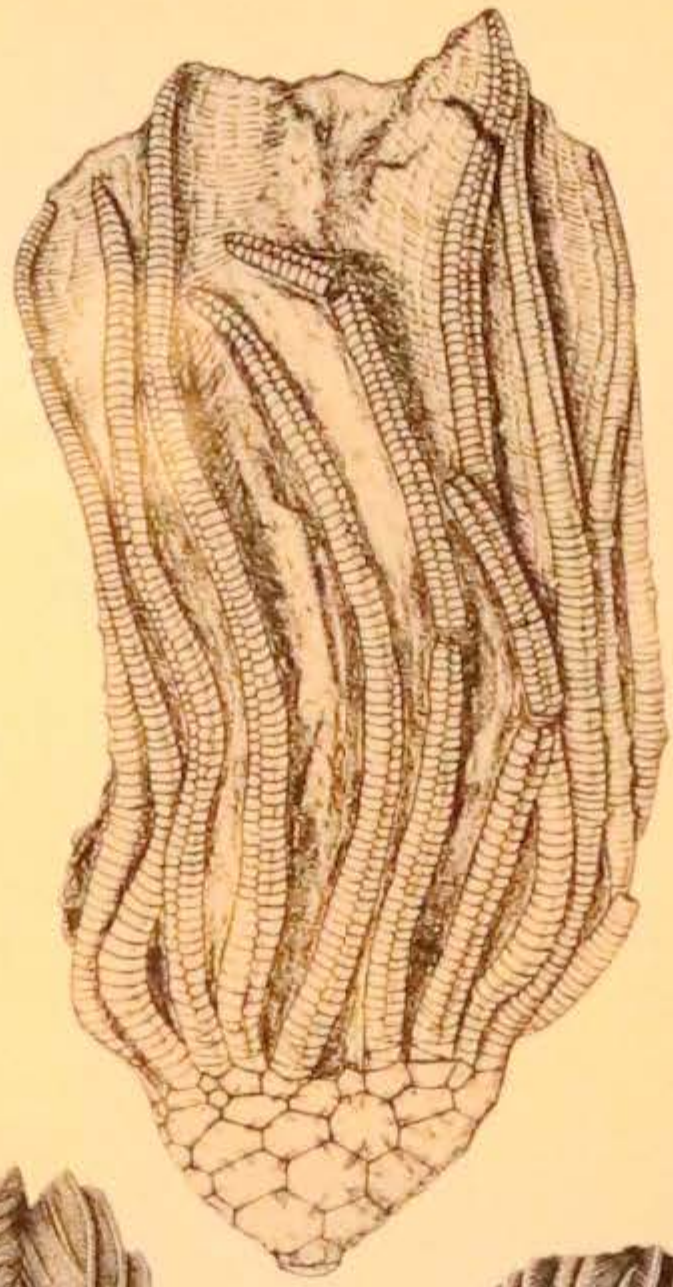

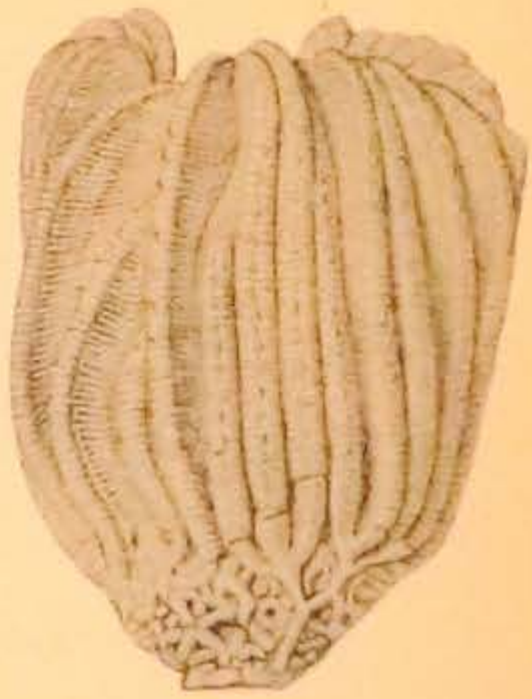

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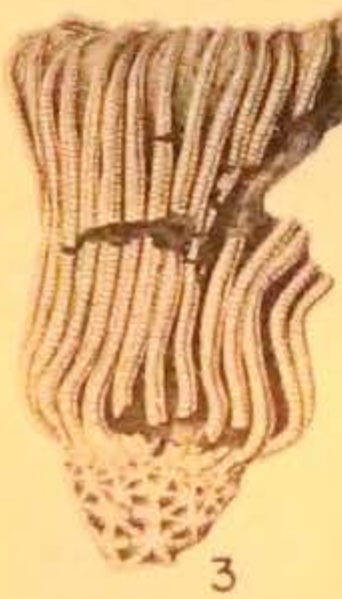

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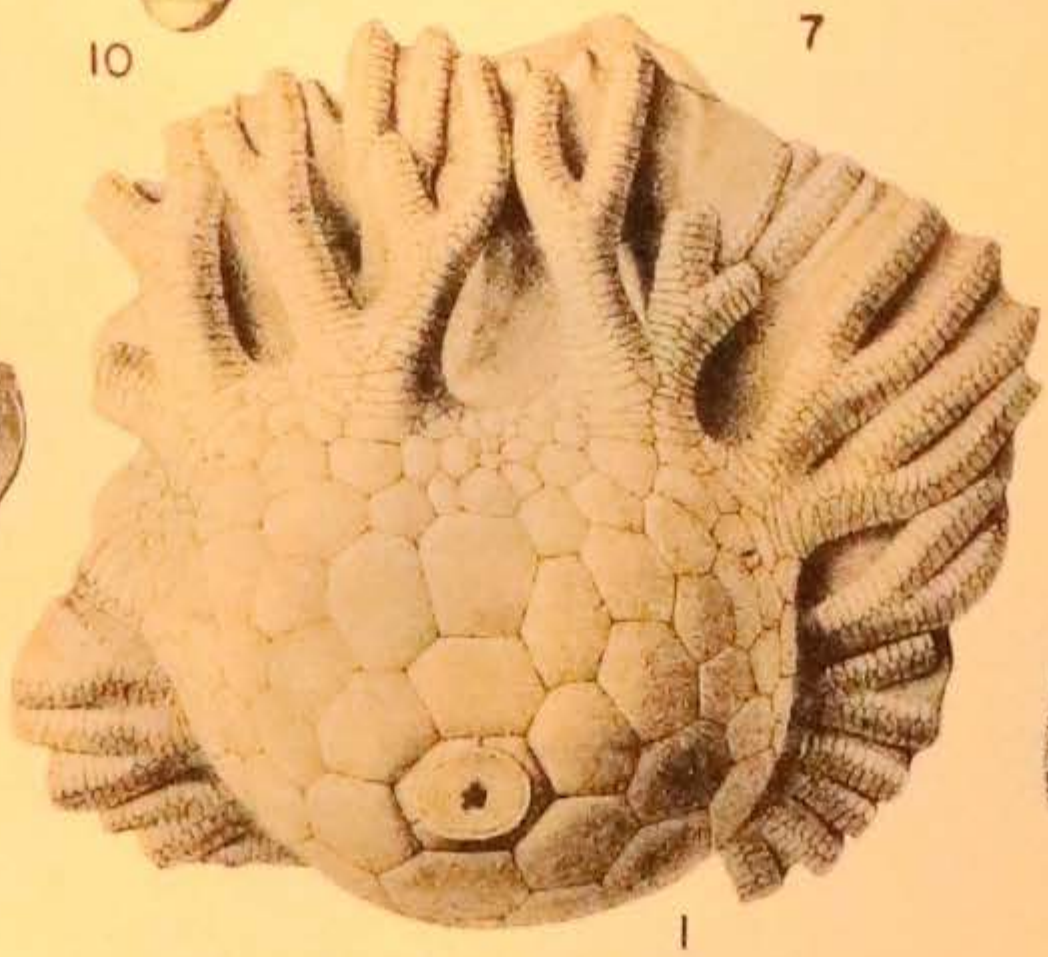

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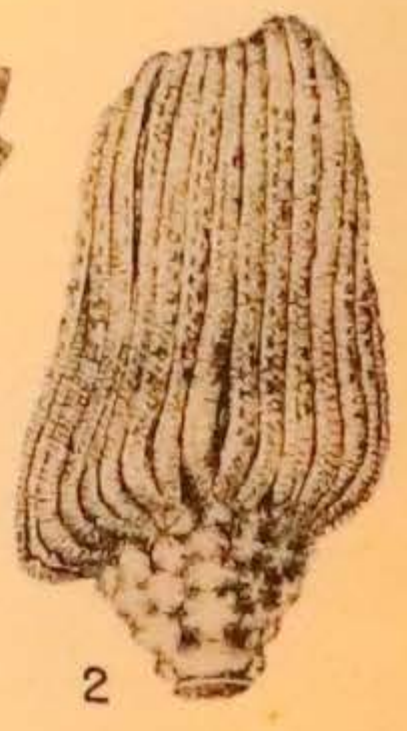

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EXPLANATION OF PLATE XVII

All specimens came from the Lower Mississippian Hampton formation near LeGrand, Iowa. All figures are X 1.

Fig. 1. *Aorocrinus immaturus* (Wachsmuth and Springer) . . 244
After Wachsmuth and Springer.

Fig. 2. *Megistocrinus parvus* Wachsmuth and Springer . . 246
Anterior view of a nearly complete specimen (Univ. Iowa 2121).

Fig. 3. *Platycrinus pendens* Springer 249
Photograph of a large specimen (Univ. Iowa 2134).

Fig. 4. *Dichocrinus delicatus* Wachsmuth and Springer . . 250
Holotype after Wachsmuth and Springer

Figs. 5, 6. *Aerocrinus primitivus* Laudon and Beane, n. sp. . . 252
Right anterior and left posterior views of the holotype (Univ. Iowa 2144).

Figs. 7, 8. *Eutaxocrinus fletcheri* (Worthen) 253
Right posterior views of two specimens after Springer.

Fig. 9. *Taxocrinus intermedius* Wachsmuth and Springer . . 252
Right posterior view of syntype after Springer.

Fig. 10. *Pachylocrinus globosus* (Wachsmuth and Springer) . . 256
Holotype after Wachsmuth and Springer.

Figs. 11, 12. *Zeacrinus infrequens* Laudon and Beane, n. sp. . . 257
Right anterior and left posterior views, respectively, of the holotype (Univ. Iowa 2159)

Fig. 13. *Scytalocrinus maccabei* (Miller and Gurley) . . . 258
Syntype after Miller and Gurley.

Figs. 14, 15. *Abrotocrinus parviglyptus* Laudon and Beane, n. sp. . 257
Posterior and anterior views, respectively of a paratype (Univ. Iowa 2158).


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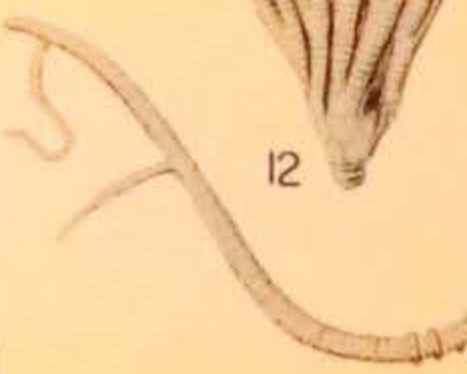
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EXPLANATION OF PLATE XVIII

All specimens came from the Lower Mississippian Hampton formation near LeGrand, Iowa. All figures are X 1.

Fig. 1. *Taxocrinus intermedius* Wachsmuth and Springer . . . 252
Left posterior view after Springer.

Fig. 2. *Pachylocrinus spartarius* (Miller and Gurley) . . . 254
Left anterior view of a large mature specimen (Univ. Iowa 2150).

Fig. 3. *Pachylocrinus legrandensis* (Miller and Gurley) . . . 256
The type of *Scaphiocrinus elegantulus* after Wachsmuth and Springer.

Fig. 4. *Pachylocrinus raymondi* Laudon and Beane, n. sp. . . 255
Holotype (Univ. Iowa 2152).

Fig. 5. *Abrotocrinus parviglyptus* Laudon and Beane, n. sp. . . 257
Anterior view of the holotype (Univ. Iowa 2157)

Figs. 6, 7. *Scytalocrinus maccabei* (Miller and Gurley) . . . 258
Fig. 6 is a syntype after Miller and Gurley; fig. 7 is an anterior view and anterior view of a mature specimen (Univ. Iowa 2161).

Figs. 8, 9. *Graphiocrinus longicirrifer* Wachsmuth and Springer . . 260
Posterior view and anterior view (showing anal tube) respectively (Univ. Iowa 2165).

Fig. 10. *Decadocrinus baumgardneri* Laudon and Beane, n. sp. . . 258
Right posterior view of holotype (Univ. Iowa 2163).

Fig. 11. *Philocrinus notatus* (Miller and Gurley) 260
Lateral view of two superimposed specimens (Univ. Iowa 2167).


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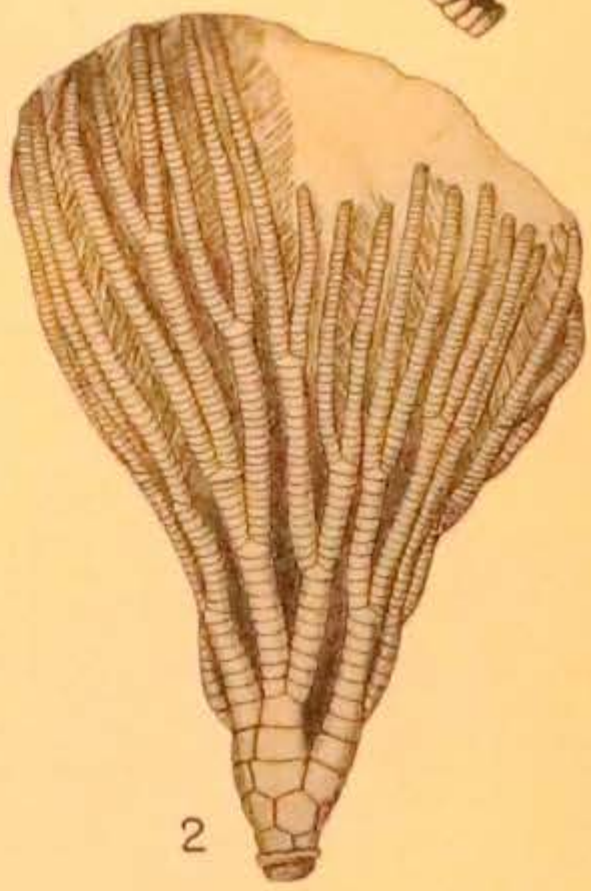
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EXPLANATION OF PLATE XIX

All specimens came from the Lower Mississippian Hampton formation near LeGrand, Iowa.

Fig. 1. *Platycrinus pendens* Springer 249
Ventral views of an excellent specimen showing tegmen (Univ. Iowa 2135). X1.

Fig. 2. *Dichocrinus cinctus* Miller and Gurley 251
Left posterior view of specimen showing column (Univ. Iowa 2168). X1.

Fig. 3. *Taxocrinus hollandi* Laudon and Beane, n. sp. 253
Left anterior view of holotype (Univ. Iowa 2146). X2.

Fig. 4. *Goniocrinus sculptilis* Miller and Gurley 254
Left posterior view of a syntype after Miller and Gurley. X2.

Fig. 5. *Pachylocrinus spartarius* (Miller and Gurley) 254
Right posterior view of mature specimen (Univ. Iowa 2151). X1.

Fig. 6. *Scytalocrinus maccabei* (Miller and Gurley) 258
The type of *Poteriocrinus hammondi* after Miller and Gurley. X1.

Fig. 7. *Gilmocrinus o'neali* Laudon and Beane, n. sp. 259
Anterior view of part of holotype, remains of which are scattered all over a large slab. (Univ. Iowa 2164). X½.

Fig. 8. *Graphiocrinus longicirrifer* Wachsmuth and Springer . . 260
Posterior view of holotype after Wachsmuth and Springer. X1.

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