

THE STRUCTURE, CLASSIFICATION AND ARRANGEMENT OF AMERICAN PALÆOZOIC CRINOIDS INTO FAMILIES.

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There have been described from North American Palæozoic rocks 1,100 species of crinoids, which are referred to about 110 genera. The arrangement of these genera into families, based upon uniform and consistent rules, is the object of this article.

When I published my work on North American Geology and Palæontology I proposed a few new family names, but as my object then was to present the state of the science as it existed, and not to write an original treatise on any one branch, I generally followed the classification of others, and as they were not in accord as to family characters, the families as there given are not of equal value. The new family names which I proposed were not defined and hence were used only provisionally, and because I could not refer the genera to families that had been limited and defined. Indeed, I did not have the time to properly classify the genera into families nor access to the fossils for the purpose of verifying such classification if I had taken the time from other duties. Since that work was done I have had an opportunity to inspect a large lot of crinoids from Mr. Gurley's collection, in addition to those in my own cabinet, and to review the various systems of classification in use in this country, and now propose to present my views of family classification.

I would desire to state, in the first place, that, in many instances, I do not agree with the views of Wachsmuth and Springer as to family characters and the classificatory value of the structural parts of crinoids, and while I may refer the same genera to some families that they do, yet the reasons therefor are not the same. I believe families should be established upon the structure of the calyx, and for this purpose the number of the basal plates is first in importance; second in importance is the presence or absence of subradials; third, the presence or absence of regular interradials, and, after this, comes the structure of the azygous side and other parts. For the purpose of showing how radically we differ, I will quote a few sentences from their work on the Palæocrinoidea:

"A subdivision according to the number of basal plates may facilitate elementary studies, but it is certainly not a natural classification."

"In the first part of this work we have discussed somewhat fully the relations of the underbasals which we took to be the product of growth in geological time, introduced gradually by interpolation between the basals. It is very remarkable that although the introduction of underbasals dates back to the Lower Silurian, as a rule, the genera in which those plates are found differ at no time materially from those in which they are wanting."

"We have, in the introduction to this work, page 17, dwelt at some length upon the basals or first ring of plates below the radials, and believe we have shown that the basal disk, whether composed of one, two, three, four or five pieces, can almost invariably be reduced to five elementary pieces, and that all deviations from this number have been produced by ankylosis of two or more of the original segments. This of itself is a strong argument against a classification based upon the number of these plates."

"It is apparent from these facts that neither the existence of underbasals, nor the modifications which took place in the basal disk, had any such corresponding effect upon the general structure of the crinoids as to entitle them to be considered characters of family importance, though in distinguishing subordinate groups they may possess some value. The radial and interradial plates are elements of far greater value."

They maintain that "a character in forms of the same geological age may be generic in one case and only specific in another," that "arm structure is of generic importance as a rule, but scarcely of specific value in exceptional cases." To neither of which views do I subscribe. So many of the opinions presented in the first part of the Palæocrinoidea are withdrawn or declared to be erroneous in the third part, and in subsequent papers, that one can not be certain, when quoting their expressions, that he is really giving their latest views, unless he is a constant student of their productions. For instance, the groove in the arms of the crinoids was almost universally covered with small plates, whether the arms had pinnules or not, but in the first part of their work they say:

"It is here important to note that in those genera in which the ambulacral groove is thus covered no regular pinnules have ever been observed, and, moreover, the construction is such that no additional pinnulæ could have existed, while on the other hand no covering has ever been discovered in forms with true pinnulæ."

After I described the plates covering the ambulacral grooves in *Glyptocrinus*, notwithstanding the long flowing pinnules, I believe they modified their views, but, at present, I have no reference to the revised opinion. Their greatest mistakes seem to me to have arisen, however, from the use of the mongrel word "*underbasals*," and a complete misconception of the purposes subserved, in the animal economy, by the plates referred to, and

the consequent neglect to give the basal plates the examination their importance demanded. They frequently discuss "rudimentary underbasals," when no such thing was ever found in a palæozoic crinoid, and from the structure of the calyx, and purposes subserved by the basal plates, "rudimentary underbasals" never could have had an existence in any of them. For instance, they say on page 7, second part, "Glyptocrinus was originally described with five basals and no underbasals. Hall afterward discovered in *G. decadactylus* small pieces concealed within the basal cavity, so rudimentary, however, that both he and Meek hesitated to call them basals, although both authors apply that term to the proximal plates in all other cases. Meek distinguished them as 'subbasals.' We have examined the plates in question very carefully in the species named, and find them, although very rudimentary, placed within the basal ring, hence they are according to our terminology, true underbasals, and not as Hall describes them, a 'quinquepartite' upper joint of the column." And again on page 186, second part, "Glyptocrinus differs from Glyptaster in having rudimentary instead of moderately developed underbasals." After I had shown that there were no such plates in Glyptocrinus, they admitted on page 102, third part, that the absence of underbasals in this genus "is clearly proved."

They said of *Heterocrinus* in the first part of Palæocrinoidea: "The absence of underbasals in some of the species is a good illustration of our views that the underbasals do not constitute elements in the structure of the Palæocrinoidea, but are merely the result of growth in geological time." Again they say: "Underbasals, minute in some species, almost undeveloped and appearing externally as subtrigonal points at the lower ends of the sutures between the basals; in some species apparently wanting entirely." But in the third part they state correctly that there are no underbasals in *Heterocrinus*, and having studied the genera belonging to the *Heterocrinidæ*, they defined them as monocyclic. It will be readily seen that where such crude and erroneous notions exist about the principal plates of a crinoid, and the same plates bear two different names, that the family classification must be imperfect, and governed by the whims of the various authors.

P. Herbert Carpenter had an opportunity of studying some living crinoids, after which, in his abuse of Dr. Hambach of St. Louis, he reasoned, through that conduit of English ignorance and conceit, "The Annals and Magazine of Natural History," as follows:

"I have the strongest conviction that the would-be interpreter of extinct fossil forms starts at a very serious disadvantage if he does not commence by obtaining the best possible information about the morphology of their nearest living representatives (as I have done). In order to understand, even with an approximate degree of correctness, extinct groups, such as the Blastoids, Merostomata, Dinosauria and others, a far more

extensive acquaintance with the recent members of the same subkingdom is necessary than for the interpretation of fossil Brachiopoda, sponges, corals, Mollusca and fishes, the morphology of which can not have differed in any important respect from that of the recent species. Without such a preliminary study no collector, however zealous, can hope to arrive at any rational conclusion (as I can) about the functions of the different structures which he may discover by the careful examination of his fossils."

I have inserted the words in parenthesis to smooth down the application to Dr. Hambach, who was completely undone by this style of reasoning, for he thought his "extinct fossil forms" were living fossils, until P. Herbert Carpenter told him most emphatically, in parenthesis, that "Mr. Hambach has never seen a living Blastoid."

As examples of the effect his study of the "living representatives" has had on his "understanding" of the "extinct fossil forms," we may refer to his morphological statement that *Hybocystites* combines Blastoid rather than Cystidean characters with those of crinoids. That *Hoplocrinus* is a synonym for *Hybocrinus*, notwithstanding there is only one azygous plate in the former, while there are two in the latter, and other important structural differences, and he at once proceeded to redefine the latter genus so as to include the former. And, speaking of *Xenocrinus*, he said: "I can not help suspecting that a better knowledge of this type (*Xenocrinus*) will lead to its absorption into *Retiocrinus*." He said: "*Hybocrinus* is a crinoid of a very embryonic type. The relatively large size of the basals and the retention of the anal plate, together with the simplicity of its arms, and the absence of pinnules, all indicate its low stage of organization." He regarded *Baerocrinus* "as a permanent larval form, which has only developed three of its five arms," and "*Hoplocrinus* is a persistent larval form." Wetherby illustrated and described the azygous plate of *Hybocrinus* as "rounded and crenulated at its distal extremity as well as much thickened." This the doughty Carpenter disposed of by saying he had received a specimen from Mr. Wachsmuth on which he could "make out little or no trace of crenulation."

It would not be necessary to point out his illiteracy, for he even uses capital letters for specific names, or lower-case, as it may happen, showing his want of a common knowledge of grammar, and recklessness in the symmetry of nomenclature, were it not for the fact that a mutual admiration society sprang up between him and Wachsmuth, and Wachsmuth adopted many of his blunders and republished them, thus giving currency to them throughout the country and injuring the progress of knowledge. It is true that Wachsmuth has refuted some of his vagaries and unwarranted conclusions, but he adheres to many of his innovations in nomenclature, though unwilling to go so far as to call all the regular interradial and vault plates oral plates and all the azygous plates anals.

The basal plates of a crinoid rest directly upon the column, and are truncated by the columnar canal, around which the animal was attached by ligaments, the scars of which are very frequently preserved. The subradial plates are never basals, nor are they in any sense homologous with the basals. In 1879, P. Herbert Carpenter, disregarding the original definition and illustration of *Heterocrinus* by Hall, and the equally plain illustration and positive statement of Billings that there were no subradial plates in the genus, or not having the sense to understand an illustration and definition, asserted there are subradials in *Heterocrinus*, and proposed to call the subradials, which had no existence, the "basal" plates, because he said they were the genital plates, and the basals he proposed to call the "*underbasals*," a mongrel word, part English and part Latin. This was a case of pure ignorance, assumption and conceit. Only one overgrown with self-conceit would propose to change the nomenclature in any branch of natural history, where no change is demanded in the interest of science, and only the most illiterate would propose in science a mongrel word formed from two languages, and only the most ignorant would select for the application of a new term an object which has no existence in nature whatever. The assertion that the subradial plates in any palæozoic crinoid are genital plates is purely gratuitous, and not warranted by any of the known facts relating to crinoids. It would have been equally as correct if he had asserted that the subradial plates were the seat of the soul, and he might have fortified the assertion by claiming that he had seen the blue ethereal substance floating around them. We were surprised, however, that he coined the word from English and Latin, for he affects profound learning in the German, and, like the politician enamored, during a campaign, of the "sweet German accent," he frequently quotes snatches from German authors, to make his usually poor English more incomprehensible. That he did not propose "*unterbasals*" for the basal plates of a crinoid, and thus make himself strong with the Germans, may have been an oversight, but if he had known the Indian tongue, he would have done himself proud by calling the basal plates "*hatapostlukbasals*," and he could have strengthened his position by commencing the word with a capital letter, as he does specific names.

Four years later he wrote that "most of the leading writers on the crinoids" had adopted his nomenclature for the plates of the crinoids, and he mentioned them. There were in all six persons, two of whom were from America, "Wachsmuth and Wetherby." It must have done the souls of Wachsmuth and Wetherby good to learn from such high authority that they constituted "most of the leading writers on crinoids," in this country. We learn from Wachsmuth and Springer's *Palæocrinoidea*, pt. 3, p. 8, that two years later Prof. Williams had joined this host of "most of the leading writers on crinoids," Wachsmuth and Wetherby. It may be in the additional five years that have elapsed since the name

underbasals" was proposed, that others have used the word to add confusion to the definition of crinoids; but it is to be hoped that each one does not constitute "most of the leading writers on crinoids" in this country. And it is high time American palæontologists would cease to look to England for information, where less is known of its own fossil crinoids than happens to be the lot of any other country in which there is any pretention to palæontological knowledge, and where more shallow pretenders vent their stupid hypotheses as to the fossil tests of these animals than exist in any other land.

Prof. D. S. Jordan, in "Science Sketches," very appropriately says: "The chief aim of the law of priority, like that of the law of primogeniture, is not the survival of the fittest, nor yet justice, but simply fixity." And the application of this rule should prevent even the most overgrown "big-head" from interfering with the long established names of the plates in the calyx of a crinoid, beside, there can be no more appropriate and truthful names than "basals" and "subradials." Subradial plates occupy a subradial position, they are neither radial nor inter-radial, but one half is below one radial series and the other half is below another radial series. Basals are always basals and never "underbasals." In some genera they are below the subradials, but in other genera the subradials extend below the basals, while the basals, in the interior of the calyx, project higher than the subradials.

There are no anal plates below the arms in the calyx of any palæozoic crinoid, and there is no more reason for calling the plates, in one inter-radial area, anals, in the present state of learning, than there is for calling them orals. The word "azygous" is applied to them because it is non-committal, and simply indicates that the plates are not the same as those in the other interradial areas. The opening in the azygous side of the vault or in the proboscis may be an anal opening, and, if so, the plates surrounding it or covering it might be called anal plates, but the name can not be applied properly to any other plates of the body. The course of evolution was progressive toward more complicated structures in crinoids, until the Subcarboniferous age; here they seem to have attained their most perfect existence. The living crinoids are the remnants, probably, of a long line of retrogression—the degenerate descendants of more highly organized ancestors—wherein some of their parts are of comparatively modern origin and others, which the ancestors possessed in a high degree, have wholly departed so that not even a rudimentary plate or scar is left to indicate the functions once exercised. Where progression has been the rule, in the development of any class of animals, we may look to the embryology and the growth of the young for reflected light on the fossil remains of past ages; but where the evolution has been backward for geological cycles of time, the study of embryology of the degenerate

descendants sheds but little light, if any, on the primitive ancestry. To speak of a fossil crinoid as "a permanent larval form" or as an "embryonic type" is, therefore, unenlightened affectation.

The basals, in all palæozoic crinoids, were the first plates to become fully developed, and, after this, they retained the same position respecting the column, through all further stages of the growth of the animal, as is shown by the uniform projection of the basal disk beyond the column, in all specimens, large and small, in the same species. It is the practice in describing the form of the basal plates to ignore the side truncated by the columnar canal and treat the plates, in description, as if they came to a point at the center of the columnar canal, which is of course never correct, and to illustrate them by cutting off the lower end so that the plates united will leave a pentagonal opening, with the angles at the suture lines of the plates, which is never correct. In fact, I never saw a correct diagrammatic view of the calyx plates of a crinoid, though the basals united are sometimes correctly illustrated. The size and form of the truncation is dependent upon the shape of the columnar canal, but the angles of the canal never unite with the suture lines of the plates; on the contrary, the rays or angles of the canal truncate the plates, and the suture lines of the plates strike the sides of the canal or extend to the body of the canal between the rays.

Wetherby described the basal plates of *Pterotocrinus* as excavated for the column and thickened and carinated at the outer edges of the columnar excavation, and I infer, from what he said, that his specimens also preserved the evidences of ligamental attachments around the canal. In the "Description of some new genera and species of Echinodermata, from the Coal Measures and Subcarboniferous rocks of Indiana, Missouri and Iowa" by myself and Mr. Gurley, it was shown that the base of *Ulocrinus* is strengthened by the thickening of the plates around the part to which the column attached and by the anchylosis of the basal plates. There is an external circular depression into which the end of the column was inserted, and this depression is surrounded by a rim to afford further strength to the point of union between the column and the body of the crinoid. At least three plates of the column were inserted into this circular depression, one of which had an extended rim beyond the column that filled a circular furrow on the interior of this depression which locked the column in the basal plates. The first plate of the column at the base of this circular depression is thin and radiately ridged to interlock with the second plate. The rays of the opening on the internal side of these plates are flanged so as to enlarge the end of the columnar canal as it passes through the basal plates. This enlarged opening is surrounded by a rim for some kind of muscular attachment and to give strength to this part of the calyx. On the outside of this rim there are radiating ligamental furrows or vascular markings for the attachment of the animal sarcode.

These characters are well shown by the illustrations. The basal plates of *Eupachyrcrinus magister* are also illustrated, showing the conical elevation in the interior of the calyx pierced at the summit by a five rayed opening for the columnar canal, with the rounded ends of the rays truncating the plates. The pentagonal opening is surrounded with ligamental scars or radiating ligamental lines, while the other parts of the internal sides of the plates are smooth. I have seen the same evidence in the basal plates of *Delocrinus*. I have the basal plates of *Glyptocrinus* showing the thickening of the plates internally around the five rayed canal and bearing evidences of ligamental attachment. It is well known that the end of the column, in all palæozoic crinoids, is so firmly attached to the basal plates, that it is rare to find a good specimen where the column has been separated from the basals leaving the place of the columnar attachment in a good state of preservation. I have before me a *Batocrinus*, with a hemispherical depression at the base, which is radiately furrowed surrounding the pentagonal opening for the columnar canal, for the firmer attachment of the column. I have a specimen of *Anomalocrinus* showing the ankylosis of the upper joints of the column and of the column with the basals, and after examining specimens in different genera, I have concluded it is not uncommon for the plates of the column, at the upper end, to be ankylosed together. The only ligamental scars in the calyx of any crinoid thus far discovered surround the columnar canal. It follows, therefore, that the basal plates are the most important in classification of any of the plates of the calyx, because the animal was attached to them, while the other plates subserved the inferior purpose of simply enclosing the other parts of the animal sarcode.

It must be apparent, therefore, that there can be no "rudimentary basals," none that are developed from the upper stem-joint, and none except they are large enough to surround the columnar canal and with area enough for the muscular attachment. The ankylosis of the basal plates is as common in genera, having no subradials as it is in those having them. It would appear that the attachment of the column to the basal plates, the passage of the columnar canal through them, and ligamental attachment on the interior held the basal plates firmly in one position, and while, in their younger state, they were capable of growing and conforming to the alternate arrangement of the plates of the column and the succeeding plates, that, in their more advanced state, the growth terminated in secreting the material that ankylosed the plates.

The earliest crinoids had five basals and such forms continued to exist throughout palæozoic time. Those having four basal plates appeared in the latter part of the Lower Silurian and disappeared in the Devonian age. Those having three basal plates appeared in the Lower Silurian and disappeared with the Subcarboniferous, and those having only two basal plates are confined to the Subcarboniferous and Coal Measures. This

statement also tends to prove the significance of the basal plates, in classification, beside, the form of the basal disk must, in all cases, control more or less the number of the succeeding plates and the structure of the calyx and body of the crinoid. For these reasons, the number of basals and the shape of the basal disk are of the first importance, and families should be so formed as to include only genera having the same number of basals and substantially the same form of the basal disk.

The second character of family importance will be found in the presence or absence of subradial plates. The only known function performed by the subradials is to increase the capacity of the visceral cavity surrounding the area of ligamental attachment to the test. In some genera, they cover half the calyx below the arms, and, in all cases, they materially affect the form and structure of the calyx and body of the crinoid. Where the plates are large, they were supported in position by ligaments in beveled sutures, as in *Eupachycrinus*, or by peculiar denticulated or serrated edges such as are found in *Arthracantha*, as illustrated and defined by Hinde, or in *Ulocrinus* as figured and described by myself and Gurley. For the purpose of classification, therefore, no family should include genera having subradials and those in which they do not exist.

The next family character will be found in the presence or absence of regular interradiial plates. These plates allow breadth to the body, and though, in their extension over the vault and in other respects, they may sometimes sink to generic or specific importance, yet the fact of their presence or absence is always of family value. The position of the first interradiial is of high classificatory value, and genera supporting the first interradials on the basal plates are never to be associated, in the same family, with those supporting the first plate between the upper sloping sides of the first radials.

The next, in family importance, are the azygous plates. The structure in this part of the body is frequently complicated and is always of generic importance and frequently of family value. For instance, a genus having an azygous plate resting on the basals is not generally to be classed, in the same family, with one having the azygous plate truncating a subradial, for the whole structure of the azygous side of the genera is different in these cases, commencing with the position of the first plate.

I regard each plate in the calyx of a crinoid to which I have attached family importance, as an independent morphological element, and, except in the specimen figured from my collection, in *Ohio Palæontology*, by Meek, under the name of *Anomalocrinus incurvus*, where there occurs an extra basal plate below the termination of a suture dividing a radial, I have always found the plates the same in each genus.

The structure of the arms, I think, is never of family importance, and above the brachials never of generic importance, though always of

specific value. An illustration or two will suffice for the demonstration of this opinion. In *Dichocrinus* we have a species with small subquadrangular pieces forming simple arms, another with arms composed of rather large cuneiform plates, and another with arms composed of a double series of interlocking plates. In *Poteriocrinus* the species have arm varying in number from ten to fifty, and the structure of the arms varies almost as much as their number does.

The shape of the column is probably of generic value. The vault and proboscis have characters of family value, but they are too little understood to base any general classification upon them. But, where they have been investigated, they afford additional evidence in support of the families established on the structure of the calyx as herein above indicated.

We will now briefly define the families based upon the structure of the calyx, without, however, undertaking to fully define them by adding all the family features that may be discoverable in the vault and column.

GENERA HAVING TWO BASALS.

FAMILY, *Dichocrinidæ*.—*Cyotledonocrinus*, *Dichocrinus*, *Talarocrinus*.

The calyx is obconoidal. Two basals form a cup slightly notched at the sutures. No subradials. Small, regular interradials on the truncated top of the first radials. Five long radial plates in the first series, succeeding radials small and resting only on part of the upper side of the first radials, the rest being occupied with interradials. Azygous plate in line with the first radials, of about the same size, supported in a notch at the sutures of the two basals, and followed by the plates of the vault. Vault more or less convex or elevated, with a subcentral opening on the azygous side. Column, so far as known, round.

FAMILY, *Pterotocrinidæ*.—*Pterotocrinus*.

Calyx saucer-shaped. Two basals form an eight sided shallow disk, notched at the sutures. No subradials. No regular interradials. First radials large, expanding from a wide base and resembling in outline the side view of an expanding bucket. The top of each first radial supports two second radials and part of two more, which rest, in part, upon the first mentioned second radials. Tertiary radials unite laterally around the top of the calyx. Azygous plate rests in a notch at the sutures of the basals, is pointed above and completely embraced by the first radials. Vault pyramidal, pentagonal, the azygous side wider than the others, the top bearing five long, peculiar, paddle-like plates arranged star-like and directed at right angles to the body, with the ends of the four arms resting in each of the angles of the five rayed dome or vault covering. Column round.

FAMILY, Acrocrinidæ.—Acrocrinus.

Calyx urn-shaped, composed of plates that increase in size from the basals up. Basals two, comparatively large, forming a polygonal shallow cup, followed, in *Acrocrinus wortheni*, by twelve minute, triangular plates all of which are subradial and subinterradial in position; these are followed by twelve larger plates, united by their lateral sides, five of which are radial in position and seven interradial, three of which are the azygous area; these are followed by a third ring consisting of fourteen plates, all of which are subradial and interradial in position; a fourth ring consists of sixteen plates, five of which are radial and the others interradial. Above the fourth ring there are two or more radials in each ray separated by interradials, all within the calyx. The number of plates in the calyx of different species varies from 100 to 700. In *Acrocrinus shumardi*, the type of the genus, instead of four rings of plates, as above defined, there are fourteen or more rings, some of which have twenty-five or thirty plates. Above these rings of small plates there are 3x5 radials, each series being separated by two or more series of interradials; the azygous area being wider and containing more plates than the others; there are also secondary radials.

The numerous rings of plates, between the basals and the commencement of the continuing series of radials, is peculiar to this genus and family, and at once distinguishes it. If the rings were united, they would occupy the position of subradials, or subradials and interradials, but such is the arrangement, that we know of no rule, which authorizes them to be treated as if united.

The three families, *Dichocrinidæ*, *Pterotocrinidæ* and *Acrocrinidæ*, having only two basal plates, are widely disconnected, and each one is so far removed from all other families that no one can be pointed out which is more nearly related to them or either of them than another. We can not infer they descended one from another, or that either of them was developed from any particular family of crinoids having three, four or five basals. We may be ever so fond of the theory of the evolution of animals and the doctrine that embryology reproduces the images of the lines of descent in geological time; but we may stop when we encounter numerous plates, in the calyx of a crinoid, whose relation and homology with plates in other crinoids we can not understand until "missing links" are discovered, before professing to have knowledge of the ancestral type.

GENERA HAVING THREE BASALS, NO SUBRADIALS, NO REGULAR INTER-RADIALS.

FAMILY, *Synbathocrinidæ*.—*Synbathocrinus*.

Calyx small, cup-shaped. Basals three, the two larger equal, pentangular, the smaller one quadrangular. No subradials. No regular interradials. Radials 1x5, truncated and thickened above. Azygous plates

resting upon one radial and between the brachials, forming a straight, narrow series of two or more plates. Brachials resembling the first radials reversed. Arms five, long, folded together, enclosing a slender proboscis composed of five rows of quadrangular plates. Column round.

FAMILY, Calceocrinidæ.—Calceocrinus, Deltacrinus, Halysiocrinus.

Calyx laterally flattened and hanging down from the column. Basals three, two are equal and form together a lunate piece, and the other plate lies within the concave side so as to make the long side of the subtriangular or half elliptical basal disk. Plates always anchylosed. The cicatrix for columnar attachment is in a lateral position in the center of the two equal plates, and does not touch the other plate. No subradials. No interradians. Calyx above the base consisting of five to seven plates, four of which are radials of unequal size and irregular arrangement.

GENERA HAVING THREE BASALS, NO SUBRADIALS, REGULAR INTER-RADIALS.

FAMILY, Actinocrinidæ.—Actinocrinus, Agaricocrinus, Alloprosallocrinus, Amphoracrinus, Batocrinus, Dorycrinus, Eretmocrinus, Gennæocrinus, Megistocrinus, Physetocrinus, Saccocrinus, Steganocrinus, Strotocrinus, Teleiocrinus.

Calyx varying from concave, as in Agaricocrinus, to obconoidal, as in Actinocrinus. Basals three, equal, having a hexagonal outline. No subradials. Primary radials 3x5, secondary radials more or less numerous, tertiary radials in some genera. Regular interradians more or less numerous, the first one resting upon the upper sloping sides of the first radials; sometimes intersecondary and intertertiary radials. Azygous area larger than the regular interradian areas, the first plate resting upon the basals, in line with the first radials and of similar form. Column round.

The learning in regard to the respiratory openings in this family is well illustrated, by the statement of Wachsmuth & Springer, on page 11, part I, of their work, that they had "noted the existence of certain pores or openings located between the arm bases and separated from the arm passages by a thin partition. Their number varies from ten to twenty or more. In Batocrinus where they are most conspicuous, there are twenty, no matter whether the species has more or less than twenty arms. They are about one-third the size of the arm passages, with which they are in very near the same horizontal plane." And the statement, on page 51, part II, where they say, in this, "they were evidently in error; the pores probably always agree in number with the arms, and are really neither radial nor interradian, but are placed at the base of the arms."

FAMILY, *Platycrinidæ*.—*Coccoocrinus*, *Cordylocrinus*, *Eucladoocrinus*, *Macrostylocrinus*, *Marsupioocrinus*, *Platycrinus*.

Calyx sub-globose to urn-shaped. Basals three, two of them equal, the other smaller, forming a pentagonal disk or cup. No subradials. First radials very large forming the greater part of the test of the calyx, the upper face of each bears a short or concave facet for the articulation of the second radials. Second, and also third radials, when they exist, small and short. Interradials and azygous interradians rest upon the first radials and are substantially alike in the different areas, column round or elliptical.

In *Macrostylocrinus*, there are 3x5 primary radials, and the first interradians are between the second primary radials, and smaller interradians occur between the third primary radials, all of which form part of the calyx below the arms, and, in this respect, it differs from other *Platycrinidæ*, where the interradians do not connect the second and third primary radials and approaches the structure of the *Actinocrinidæ*. It has little structural affinity with the *Melocrinidæ* which have four basals, and to which Wachsmuth referred it. But Wachsmuth disregarded the number of basals to a great extent in arranging and defining the families, and his definitions are so loose that crinoids, belonging to distinct and widely disconnected families, may be thrown together in hodge-podge. For example his definition of the *Melocrinidæ* is as follows:

“*Melocrinidæ*. Base monocyclic. Basals 3 to 5. Neither anal nor interradian plates touching the basals; the latter in contact with radials only. Interradian areas composed of numerous plates; those upon the dorsal side large, regularly arranged; those along the ventral surface frequently small and irregular. Oral plate generally surrounded by proximals. Anus sub-central. Column circular, rarely angular.”

FAMILY, *Dolatocrinidæ*.—*Alloocrinus*, *Dolatocrinus*, *Hadroocrinus*, *Stereoocrinus*.

Calyx, basin-shaped, or somewhat hemispherical, depressed at the base. Basals, three, usually ankylosed so as to create doubt as to the number. No subradials. Primary radials 2 or 3x5; secondary radials two or more by ten, tertiary radials sometimes present. Azygous and regular interradians areas alike. Interradials, three or more, the first resting between the upper sloping sides of the first radials, the larger, and generally the largest, plate in the calyx, truncated on top for the second interradian which bears smaller plates. Arm openings, large. Small subcentral proboscis. Column, round.

Wachsmuth & Springer refer the genera in this family to the *Melocrinidæ*. *Dolatocrinus* was supposed by Lyon to have five basal plates, but Wachsmuth and others assert it has only three, and it is upon their

statements, in this regard, that this family is founded, for I have never seen a specimen that preserved the basals, though I have imperfect specimens of *Dolactocrinus lacus* and would guess from an examination of them that they have only three basals.

FAMILY, *Arthracanthidæ*.—*Arthracantha*.

Calyx, cup-shaped. Basals, three, subequal, hexagonal in outline. No subradials. First radials subequal, very large, forming the greater part of the test of the calyx, each one thickened in the middle and having a concave, ridged facet for the articulation of the second radial, which is a short quadrangular plate reaching but little above the margin of the first radial; third radial short, pentagonal, and bearing the free arms. Regular interradians consist of three zones of three or four plates each, in each area, resting upon the first radials and between the second and third interradians. The middle plate in the zone resting upon the first radials is the larger one, and the plates on either side of it are larger than those above. The first azygous plate rests upon two basals in line with the first radials and is nearly as large, but a little narrower at the upper margin, which is on a level with the first radials. Above this plate, in the azygous area, there are three zones of plates; in the first zone there are six and in succeeding zones seven; column, round. All the plates of the calyx bear articulating spines, the bases of which are perforated with a minute circular pit as in the *Echinida*, and as *Hambach* determined in some, *Blastoidea*. This character alone is probably of family importance, as it is not known to exist in any other family of crinoids, living or fossil. Otherwise the basals, first radials and first azygous plate would ally it with the *Actinocrinidæ* and the plates above with the *Platycrinidæ*.

Wachsmuth & Springer classed this family with the *Dichocrinidæ* and *Pterotocrinidæ*, in one family, which they called *Hexacrinidæ*. There are not three families, in my opinion, farther removed from each other in all the Palæocrinoidea. Their family definition is as follows:

“*Hexacrinidæ*. Base monocyclic. Basals 2 or 3. First anal plate resting on basals and similar in form to first radials; other plates arranged as in *Platycrinidæ*. Calyx with similar arm-like extensions. Column circular.”

Let us see what there is in this family definition. 1st. They say, “base monocyclic.” So is the base in every crinoid that has no subradials. In other families they include monocyclic and dicyclic crinoids, which embrace nearly the whole order. 2d. “Basals 2 or 3.” This disregards the number of basals as a family character, and, in another part of their work, they say the number of basals can not be considered as of family importance; and yet, crinoids having only two basals are

unknown in rocks as low as the Devonian, and *Arthracantha* is exclusively a middle Devonian genus. 3d. "First anal plate resting on basals and similar in form to first radials." It is the same in the *Actinocrinidæ*. 4th. "Other plates arranged as in *Platycrinidæ*." Such is not the case in the *Pterotocrinidæ*, by any stretch of the imagination. 5th. "Calyx with similar arm-like extensions" This can not be true for they include arms constructed of single and double series, arms widely separated and closely compacted; arms free, flowing, and those confined in interbrachial angles, and in short, almost every form is represented. 6th. "Column circular." This is the case in nearly every family.

GENERA HAVING THREE BASALS, SUBRADIALS, NO REGULAR INTER-RADIALS.

FAMILY, *Ichthyocrinidæ*.—*Ichthyocrinus*, *Lecanocrinus*, *Mespilocrinus*.

Calyx obconoidal to sub-globose. Basals three of unequal size. Subradials five, pentagonal and hexagonal. Primary radials 2, 3 or 4x5. Secondary radials more or less numerous, and higher bifurcating series abutting laterally. No regular interradials. Azygous interradials usually absent in *Ichthyocrinus*, one subquadrangular and resting upon the larger basal, as in *Mespilocrinus*, or two, one of which rests obliquely in the angle formed by the upper sloping sides of two subradials on the right, and the other truncating the subradial on the left, as in *Lecanocrinus*.

FAMILY, *Ampheristocrinidæ*.—*Ampheristocrinus*, *Closterocrinus*?

Calyx obpyramidal. Basals three, two truncated on top, the other much smaller and angular above. Subradials five, two hexagonal, two pentagonal, and one heptagonal, the latter the larger one. Primary radials, one in each series, with a small central concavity for the reception of a second plate, as in *Platycrinus*. No regular interradials. Azygous area large, having six or more plates, the first one rests obliquely upon the right upper sloping side of the heptagonal subradial and the under sloping side of the right first radial, the second one truncates the same subradial, and these bear smaller interradials. *Closterocrinus* is referred with some doubt to this family. Wachsmuth referred *Ampheristocrinus* to the *Cyathocrinidæ* and did not mention *Closterocrinus*.

GENERA HAVING THREE BASALS, SUBRADIALS, AND REGULAR INTER-RADIALS.

FAMILY, Taxocrinidæ.—Forbesocrinus, Onychocrinus, Taxocrinus.

Calyx saucer to cup-shaped. Basals three, of unequal size. Subradials five, unequal. Primary radials more or less numerous, the first one sometimes reaching as low as the basals and completely disconnecting the subradials. Regular interradials from one to twenty or more. Azygous area larger than the regular interradial areas and plates more numerous, the first plate in some genera truncates a subradial, and in others rests between the upper sloping sides and the first radials.

In *Taxocrinus subovatus* the basals form a pentagon extending beyond the column, the subradials are small triangular plates, separated from each other, so as to allow the first radials to rest upon the basals, at the central part, with under-sloping sides abutting the adjacent subradials.

GENERA HAVING FOUR BASALS, NO SUBRADIALS, REGULAR INTER-RADIALS.

FAMILY, Eucalyptocrinidæ.—Eucalyptocrinus, Hypanthocrinus.

Calyx bowl-shaped to obconoidal with depressed base. Basals four, one larger than the others, deeply sunken in the basal cavity and developed in the interior. No subradials. Primary radials 3×5 ; secondary radials 2×10 ; tertiary radials 1×20 . Interradials three, the first one is the largest plate in the calyx, and always has ten sides; the other two are separated by a verticle suture and their upper ends extend to the top of the tertiary radials, where they support long, flat, interbrachial plates; intersecondary radials, in form like the two upper regular interradials, in like manner extend to the top of the tertiary radials and support long, interbrachial plates. Azygous area like the other interradial areas. Interbrachial plates extend from the top of the interradials as high as the arms reach, where they unite with the summit plates. Column round. After a re-examination of the fossils, I think the genus *Hypanthocrinus* should be restored to receive those forms with a proboscis extending beyond the arms and summit plates.

FAMILY, Melocrinidæ.—Compsocrinus, Mariaocrinus, Melocrinus, Technocrinus.

Calyx bowl-shaped to obconoidal. Basals four, unequal. No subradials. Primary radials 3×5 ; secondary radials more or less numerous, and sometimes, as in *Compsocrinus*, many tertiary radials. Interradial, intersecondary and intertertiary areas more or less flattened or depressed. First regular interradial resting upon the upper sloping sides of the first radials, followed by two plates and these by three, above which the plates

are more or less numerous. Azygous area wider than the regular areas, the first plate resting upon a basal or between the first radials, and generally followed by three plates, and these by three or four, above which they are more or less numerous. Vault variable. Column round, as in *Melocrinus*, or quadrangular with depressed sides, as in *Compsocrinus*. It is not without some doubt that *Compsocrinus* is referred to this family, because the azygous side, upper part of the calyx, and the column are quite different from other genera. *Technocrinus* is also doubtfully referred to this family, because in it, the azygous area is like the other areas, and the upper part of the calyx is widely different from *Melocrinus*.

FAMILY, *Xenocrinidæ*.—*Xenocrinus*.

Calyx, obpyramidal, sides depressed. Basals four, unequal, uniting at the angles of the column. No subradials. Primary radials 3×5 , long, flanged on both sides; secondary radials, four or more in each series of the same form. Interradial and intersecondary radial areas, depressed and covered with numerous very small plates. The first interradian generally rests upon a basal, but in some cases it is separated therefrom by a narrow prolongation of the flanges near the lower part of the first radials, and hence, rests upon the lower part of and between the first radials. Azygous area contains a vertical series of long plates, nearly as long as radials, in its central part, supported upon a basal plate and extending beyond the calyx, and on each side of it there are numerous very small plates, as in the regular interradian areas. Column quadrangular, but sometimes becoming round below. Columnar canal pentagonal.

GENERA HAVING FIVE BASALS, FIVE SUBRADIALS, NO REGULAR INTERRADIALS.

FAMILY, *Cyathocrinidæ*.—*Abrotocrinus*, *Arachnocrinus*, *Bursacrinus*, *Carabocrinus*, *Cyathocrinus*, *Graphiocrinus*, *Palæocrinus*.

Calyx saucer, hemispherical or bowl-shaped, depressed below. Basals five, equal, varying from a flattened disc to a cone in the interior of the calyx. Subradials five, large. Primary radials 1×5 , large; the one on the right of the azygous side, usually the smaller one, truncated on the top, and usually having a concave facet in the central part of each for the support of the brachials, but in *Abrotocrinus*, *Bursacrinus* and *Graphiocrinus*, the articulation is upon the whole upper horizontal face, as in *Poteriocrinidæ*, with an external gaping suture. No regular interradians. Azygous plate resting upon the upper edge of a subradial and between two radials. Column round or pentagonal.

Carabocrinus is included in this family on the supposition that Billings was mistaken in saying the azygous area has three plates instead of one. If, however, his diagnosis was correct the genus would belong to another family.

I have separated from the Cyathocrinidæ the Poteriocrinidæ, on the ground of the increased number of plates in the azygous area, and the fact that one of them rests upon two subradials, and another upon one; confining the Cyathocrinidæ to those having a single azygous plate truncating a subradial. If this distinction is not of family importance, then the Poteriocrinidæ should be associated with the Cyathocrinidæ, as most authors have done. As a general rule the calyces of the Poteriocrinidæ are obconoidal from the attachment of the column up, and the bases of the Cyathocrinidæ are sunken, giving the calyces a bowl-shape, but this rule has its exceptions, so that families can not be based upon it.

FAMILY, Poteriocrinidæ.—Atelestocrinus, Barycrinus, Coeliocrinus, Euspirocrinus, Goniocrinus, Homocrinus, Hydreionocrinus, Poteriocrinus, Scaphiocrinus, Vasocrinus, Zeacrinus.

Calyx obconoidal to bell-shaped. Basals five, equal, forming a flattened disc or low pentagonal cup, with high angles between the subradials. Subradials five, unequal. Primary radials 1x5, horizontally truncated upon the upper face for the articulation of the brachials. No regular interradials. Azygous interradials two or more, the first one resting between two upper sloping sides of subradials and below the under sloping side of the first radial on the right, the second one abutting upon the first, truncating a subradial and abutting upon the first radial on the left. In such genera as Barycrinus this plate also abuts upon the first radial on the right and extends to the top of the calyx. But in genera having three azygous plates the third one rests upon the first, abuts upon the second one on the left and the first radial on the right; and if a fourth plate exists it rests upon the second, abuts the upper part of the first radial on the left and the first brachial and the third azygous plate on the right. Where three or more plates form part of the calyx they are arranged alternately in two rows, and continue into and form part of the ventral sac or proboscis.

I have classed Hydreionocrinus and Zeacrinus in this family with some doubt. They differ in the general construction of the vault and in the arrangement of the azygous plates from other genera, and probably they constitute a separate and distinct family, though I believe all American authors have classed them with Poteriocrinidæ.

FAMILY, Dendrocrinidæ.—Dendrocrinus, Ottawacrinus.

Calyx obconoidal. Basals five, equal, forming a low pentagonal cup. Subradials five, unequal. Primary radials 1x4 and 1x2, horizontally truncated or having a concave facet for the articulation of the arms. No regular interradials. Azygous interradials one, truncating a subradial followed by a double series of plates that graduate into the proboscis. This family is distinguished from the Cyathocrinidæ and Poteriocrinidæ

by having two primary radials on the right of the azygous plate instead of one. Otherwise the form of the calyx is like that of a *Poteriocrinus* and the azygous plate like that of a *Cyathocrinus*. The many species of *Dendrocrinus* and variety of forms lead to the separation into a family, for convenience of classification, beside no *Poteriocrinus* is found in the Lower Silurian rocks, where *Dendrocrinus* prevails, and only one rare genus (*Euspirocrinus*), referred to the *Poteriocrinidæ*, exists in the rocks of that early age.

FAMILY, *Eupachyrcrinidæ*.—*Æsiocrinus*, *Delocrinus*, *Eupachyrcrinus*, *Ulocrinus*.

Calyx, somewhat hemispherical, flattened or depressed at the base. Basals, five, equal, sometimes forming an interior cone. Subradials, five, very large. No regular interradials. From one to three azygous interradials, when only one exists, it truncates a subradial and rests between first radials, as in *Cyathocrinus*, but when two or more exist they are arranged much like they are in *Poteriocrinus*, though the first plates situate between the upper sloping sides of the subradials and below the primary radial on the right, may be larger than a primary radial, which is never the case in the *Poteriocrinidæ*. The primary radials are truncated at the upper edge, and have a straight hinge line from one junction of the plates to another for the articulation of the first brachial plates, which are generally spine-bearing. The primary radials, when viewed from the interior, are arched over part of the visceral cavity, but as seen from above they extend beyond articulating hinges toward the center of the vault, as a platform, upon which the proboscis is supported. There are no vault plates in this family. The azygous plate at the top of the calyx extends its flange over the visceral cavity like a primary radial and supports a series of plates that make an azygous side to the proboscis. I have placed in this family genera differing in the azygous area and in the number of azygous plates, but the calyces are similar in form, otherwise, and the primary radials are alike in the articulating hinge, for the brachials and flattened surface or platform within for the support of the proboscis, which I consider of high importance in the structure of the internal anatomy. The column is round, the columnar canal five-rayed, and in the interior of the calyx it is surrounded with muscular scars, and the basal plates are ankylosed in all the specimens I have examined in this family.

Wachsmuth & Springer referred this family to the *Cyathocrinidæ* in the first part of their book, but in the third part they refer the genera to the *Poteriocrinidæ*.

FAMILY, *Erisocrinidæ*.—*Erisocrinus*, *Menocrinus*, *Stemmatocrinus*.

Calyx, somewhat hemispherical or globose. Basals, five, equal. Subradials, five, equal. Primary radials, five, equal. No regular inter-

radials. No azygous interradials. In *Erisocrinus* and *Stemmatocrinus* the primary radials have the form of those in *Eupachyrcrinidæ*, but in *Menocrinus* they are like those in *Cyathocrinus*. This family is distinguished from both, however, by not having an azygous plate within the calyx which, I suppose, necessarily involves important structural modifications in the internal anatomy of the animal.

Menocrinus (*Lecythiocrinus*) *adamsi*, as illustrated by Worthen (Ill. Geo. Sur., vol. VII, pl. XXX, fig. 8), has five basals, but *M. olliculiformis*, as defined by White, possessed only three basals. White had only a single specimen, and some imperfection may have misled him, for if it possessed only three basals the two species are not congeneric, and the latter could have no near affinity with any defined family, as *Taxocrinidæ* is the only one having three basals and five subradials.

Wachsmuth & Springer, in the third part of their work, refer *Menocrinus* to the *Cyathocrinidæ*. In the first part of their work they refer *Erisocrinus* and *Stemmatocrinus* to the *Cyathocrinidæ*, but in the third part they refer them to *Poteriocrinidæ*.

FAMILY, *Agassizocrinidæ*.—*Agassizocrinus*.

Calyx conical or urn-shaped. Basals five, thick, usually anchylosed, very small internal cavity, in which there are ligamental pits. Subradials five, large, thick. Radials 2x5. No regular interradials. Azygous interradials three or four, supported upon the basals. In the early stage of life *Agassizocrinus* possessed a small column, but in later life even a cicatrix for the columnar attachment is obliterated. I do not use *Astylocrinidæ*, because it was founded upon *Astylocrinus*, which is a synonym for *Agassizocrinus*, and as the generic name falls into synonymy, so does the family name. Wachsmuth & Springer use *Astylocrinidæ*.

FAMILY, *Merocrinidæ*.—*Merocrinus*.

Calyx very low, broad at the base, slightly expanding. Basals five, low, wide. Subradials five, short, wide. Radials 1x4 and 1x2, one radial series having two plates, the upper one of which is axillary, and supports on its right sloping side a brachial series, and on the left a smaller series that enters into and forms part of a proboscis, and in this respect the arrangement of the plates is like an *Iocrinus*. No regular interradials. No azygous interradials. Brachials numerous.

GENERA HAVING FIVE BASALS, FIVE SUBRADIALS, REGULAR INTERRADIALS.

FAMILY, *Gaurocrinidæ*.—*Gaurocrinus*, *Reticrinus*.

Calyx obpyramidal, depressed in the interradial and intersecondary radial areas, and having strong radial ridges. Basals five. Subradials five. Primary radials 3x5. Secondary radials from 2 to 6x10. Regular

interradial areas filled with numerous small plates resting upon the subradials. Secondary interradial areas filled with numerous small plates. Azygous area larger than the regular areas, and supported by a ridge up the middle series of plates, somewhat like a radial ridge. Vault covered by small plates, which are continued as a covering over the arm furrows. Column pentagonal, with sides more or less depressed.

FAMILY, Rhodocrinidæ.—Archæocrinus, Goniasteroidocrinus, Lyriocrinus, Rhaphanocrinus, Rhodocrinus.

Calyx subglobose or hemispherical. Basals five, forming a flattened disc or developed as a cone in the interior. Subradials five, equal. Primary radials 3x5. Secondary radials 1 to 4x10. Regular interradial areas wide, plates large, the first one resting upon a subradial and between the first primary radials. Azygous area like the regular areas except an occasional extra plate or two, without disturbing the general symmetry of the calyx.

It is not without some doubt that Archæocrinus and Rhaphanocrinus are referred to this family.

FAMILY, Glyptasteridæ.—Glyptaster, Lampteroocrinus, Thysanocrinus.

Calyx obpyramidal to cup or urn-shaped. Basals five, equal. Subradials five, four of them equal, the other one truncated for the support of the first azygous plate. Primary radials 3x5. Secondary radials variable in number in different genera. Interradial areas flattened or convex; plates large, one in the first series resting between the upper sloping sides of the first radials, two in the second and smaller ones above. Azygous area wider, the first plate resting on a subradial, is followed by three plates, and these by three, four or more in succeeding ranges.

GENERA HAVING FIVE BASALS, NO SUBRADIALS, REGULAR INTERRADIALS.

FAMILY, Glyptocrinidæ.—Cupulocrinus, Glyptocrinus, Pycnocrinus, Schizocrinus, Siphonocrinus. (?)

Calyx obpyramidal. Basals five, equal. No subradials. Primary radials 3 or 4x5, the last one supporting secondary radials, and sometimes tertiary radials exist within the calyx. Interradial areas more or less flattened. Regular interradials more or less numerous, the first one resting between the upper sloping sides of the first primary radials, this is followed by two plates, and there are three or more in succeeding series. Azygous area wider and containing more plates than the regular areas, though commencing with one between the upper sloping sides of the primary radials.

I am inclined to think that *Siphonocrinus* should be classed in another family, because the first azygous plate rests upon the basals, and for other structural differences. It is placed here only provisionally.

FAMILY, *Cleiocrinidæ*.—*Cleiocrinus*.

Billings described *Cleiocrinus* as having five basal plates between the first radials, and forming a belt at the end of the column. I reproduced his illustration in *North American Geology and Palæontology*. Wachsmuth correctly asserts that "such a structure has never been found in any crinoid." I believe with Wachsmuth that the plates supposed to be basals by Billings are interradians, but beyond this I can not follow him. He believes this genus had three very small basals and five small subradials, and he has given us an illustration of his views, which obliterates the columnar canal. I am unable to understand why he should suppose there are three basals and five subradials when such a structure is wholly unknown in the Lower Silurian rocks. Indeed three basals, five subradials, regular interradians and azygous interradians are known to exist only in three genera, and they belong to the Subcarboniferous age. I suppose *Cleiocrinus* had five basals and no subradials. And even with this structure it would be so far removed by reason of the arrangement of the plates constituting the calyx that it would constitute a distinct family.

GENERA HAVING FIVE BASALS, NO SUBRADIALS, NO REGULAR INTERRADIALS.

FAMILY, *Heterocrinidæ*.—*Ectenocrinus*, *Heterocrinus*, *Ioerinus*, *Ohioerinus*.

Calyx obconoidal. Basals five, unequal. No subradials. No regular interradians. Azygous interradians not reaching the basals, but resting upon the upper sloping sides of the first radials. Primary radials irregular, and varying in number, in the same genus, the right posterior radial in some cases resting upon an azygous plate, and in *Ioerinus* a radial plate supports on its right sloping side a series of brachial plates and on its left a series of quadrangular plates that graduate into and form part of the proboscis or ventral tube.

FAMILY, *Anomalocrinidæ*.—*Anomalocrinus*.

Calyx, saucer or cup-shaped. Basals, five. No subradials. No regular interradians. A subquadrangular azygous plate situate between the lateral sloping sides of the two first radials, unites with them by a serrated edge and curves over toward the vault. One primary radial in three rays and two in each of the other two rays. The arms are wide apart and the radials, between the arms, curve over the edge of the vault. There is only one genus known. The calyx is low and wide, plates large,

column large, different from any other known, arms also differing from all others and bearing pinnules only on one side, from one arm bifurcation to the next, alternately.

The diagram of *Anomalocrinus incurvus* by Meek, in the Ill. Geo. Sur., vol. 3, p. 327, and reproduced in my work on North American Geology and Palæontology, p. 324, is incorrect, if the specimen figured in the Ohio Palæontology, vol. 2, from my collection, under the same name, belongs to the same species. The columnar canal is large and five-rayed. The second and third azygous plates form a part of the vault covering.

FAMILY, *Belemnocrinidæ*.—*Belemnocrinus*.

Calyx, cup-shaped. Basals, five, large, long, narrow and of irregular shape, enclosing a very small visceral cavity. No subradials. Radials 1x5 smaller than basals. No regular interradians. Azygous plate like a radial, in line with them, resting upon a basal between two radials and supporting a ventral sac.

FAMILY, *Catilloocrinidæ*.—*Catillocrinus*.

Calyx, bowl-shaped. Basals, five, forming an irregular pentagon, three of the sides being much the longer. Radials 1x5, very irregular in form and size, the two larger ones constitute three-fourths of the circumference at the top of the radials, but are narrow below, while the others diminish in width upward. The arms rise directly from the truncated summit of the radials and are quite compact, so that some radials support a much larger number of arms than others do. No regular or azygous interradians.

FAMILY, *Hybocrinidæ*.—*Hybocrinus*.

Calyx bulged or tumid on one side. Basals five, large. One plate half subradial in position, in line with four first radials, but not extending quite so high and bearing upon one upper sloping side a radial, and upon the other an azygous plate which is rounded and crenulated at its distal extremity, as well as much thickened. No regular interradians.

FAMILY, *Haplocrinidæ*.—*Allagecrinus*, *Haplocrinus*.

Calyx cup-shaped. Basals five. No subradials. No interradians. No azygous plates. Primary radials 2x3, plus 1x2, with small protruding concave facets in the upper truncated sides for the attachment of the arms; the upper face of these plates support five vault plates that form a pyramid over the visceral cavity of the calyx. The sutures of the vault plates are beveled, shallow in the lower part, wider and deeper above, and truncate the top of the pyramid.

Carpenter regards *Haplocrinus* as "permanently in the condition of a Pentacrinoid larva with a closed tentacular vestibule." Wachsmuth & Springer fully agree with him that *Haplocrinus* is "a persistent larval form, but do not understand how the five large plates can represent the orals in a Palæocrinoid." Neither does any other one. The permanent larval form is equally absurd.

Wachsmuth & Springer refer *Allagecrinus* to the *Haplocrinidæ*, while Etheridge & Carpenter referred it to the family *Allagecrinidæ*, and I followed the latter in my work on North American Geology and Palæontology, but probably the former are correct.

FAMILY, *Pisocrinidæ*.—*Pisocrinus*.

Calyx globular. This family has five basal plates, forming a subequilateral triangle, in the type species, three are triangular and two are quadrangular, but in the American species this is reversed. In the type species, two plates unite in an angle of the triangle, and only one side of the triangle is formed by three basal plates, the other two sides each being formed by two sides of the basal plates, but in the American species, two sides of the triangle are made by the sides of three basal plates and one by the sides of two basals. In the second series there are only three plates, which form the principal part of the calyx, and they partake of the characters of both subradials and radials; one of them bears upon its upper sloping sides, small, radial plates, and is, therefore, a true subradial; the other two bear radial plates upon their upper lateral sides, but each are also truncated in the upper central part for a brachial or arm plate, and, therefore, two plates are both radial and subradial in position. There are, therefore, three small true radial plates, and two large plates, radial in the central part of each, so that the crinoid has only five arms. No radial plate is truncated entirely across the upper face, but in all cases the first brachial or arm-plate rests in a socket with a point of the radial supporting it on each side. The column in all known species is round and the plates of the calyx remarkably thick, especially in the lower half.

There is no other American crinoid having basals that form a triangle, nor having five basals followed by a second series of only three plates, nor having a second series composed of plates, both radial and subradial, in position.

FAMILY, *Edriocrinidæ*.—*Edriocrinus*.

Calyx cup-shaped. The base is solid in *Edriocrinus*, and, therefore, if it ever consisted of more than one plate, the number is unknown, and it constitutes nearly all of the calyx. There are five radials resting in depressions in the base. No regular interradials. An azygous plate, in line with the radials, rests in a basal depression and extends as high as the radials; it is followed by a small plate. But little is known of this family.

FAMILY, uncertain.

The fossil described by Hall under the name of *Myrtillocrinus americanus* belongs to an undefined genus. The definition of the species is probably incorrect, for in all known palæocrinoidea the rays of the columnar canal notch the basal plates, and this species is figured as having a four-rayed canal and described as having five basals. Probably other specimens will show that it has only four basals, for otherwise it will be quite anomalous, and in either event it is not a *Myrtillocrinus*.

Nipterocrinus was placed by Wachsmuth in the *Icthyocrinidæ* without knowing the number of basals in the genus, and Zittel referred it to the *Cyathocrinidæ* upon equally as good grounds. Until we know whether it has three or five basals, any family reference must be provisional and of little value.

Camarocrinus doubtless belongs to a family *Camarocrinidæ*, but it is so far removed from other crinoids that it may belong to a distinct order. *Ancyrocrinus*, *Aspidocrinus*, *Brachiocrinus*, *Coronocrinus*, *Cystocrinus* and *Pachyocrinus* are genera about which very little is known.