Study of Biological Principles Indicated by Fossils and the Planning of Exhibits to Illustrate these Principles

BY

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STUDY OF BIOLOGICAL PRINCIPLES INDICATED BY FOSSILS AND THE PLANNING OF EXHIBITS TO ILLUSTRATE THESE PRINCIPLES.

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As part of the work for the course, Geology 203, material was gathered for exhibits which are to be placed in the Paleontological Museum's exhibit hall. The fossils used are from the paleontological collections.

An attempt has been made in the exhibits to present principles which will be comprehensible not only to the student of geology, but to the average museum visitor. Despite the dual purpose it is hoped that both groups can profit from the information given.

Although emphasis has been placed on ideas and principles rather than facts, each statement has beeen checked to see that it contains only the latest and most exact information available.

Plans have been made for the following exhibits:

1. Development of graptolites.
2. Dependence of animals as shown in paleontology.
3. Adaptive modifications of crinoid and cystid stems.
4. Development of cephalopods.
5. The relationships of brachiopod genera.

The labels and explanatory sheets which are to be placed with the fossils in the exhibits are included on the pages which follow.

Exhibit: The Development of Graptolites

The exhibit explaining the evolutionary development of graptolites has necessarily been supplemented by a description of the class Graptozoa since there are no other specimens of graptolites on exhibit in the hall.

A generallized life history of a graptolite is given and distinction made between the three main subdivisions. These biological descriptions are to be placed in the accessory case above the table case containing the fossils used to illustrate the development trends. Three fossil specimens, a representative of each subdivision of the class and an example of graptolites preserved in limestone are to be placed at the beginning of the exhibit as a transition from the life histories to the main fossil exhibit.

The evolutionary trends are illustrated by two lines of development:

(1.) The change in the position of the branches from pendent to erect.

(2.) The reduction in the number of branches.

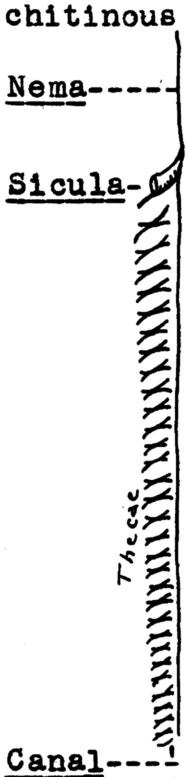
The labels for the life histories are given first, followed by the labels to be used with the fossils, in the order in which they are to appear.

Class Graptozoa - The Graptolites

Graptolites comprise an extinct class of the Phylum Coelenterata which includes such living forms as corals, jelly fishes, and sea anemones.

The first graptolites are found in Cambrian rocks in which they are represented by few individuals. Many are present in the Ordovician strata, deposited during the time of the greatest development of these animals. Silurian rocks contain a much smaller number, the Devonian strata exhibiting the last known graptolites.

Graptolites are found on the bedding planes of black shales and limestones, as shiny black films, the carbonized remains of the horny chitinous skeletons of the animals.



Each graptolite is a colony consisting of a series of individuals or polyps living in pits along a chitinous branch. The colony originates from a single polyp whose conical skeleton, the sicula, is attached to some object by a hollow, thread-like tube, the nema. The colony grows in a linear manner by the addition of new polyps.

The skeletons of the polyps, the thecae, are small and usually arranged with their walls in contact, opening at their bases into a common canal.

The simpler earlier forms were sometimes attached to the sea bottom, but more often to floating objects, especially seaweeds. The later, more specialized forms developed floats of their own and were distributed by ocean currents.

The class Graptozoa is divided into two orders:

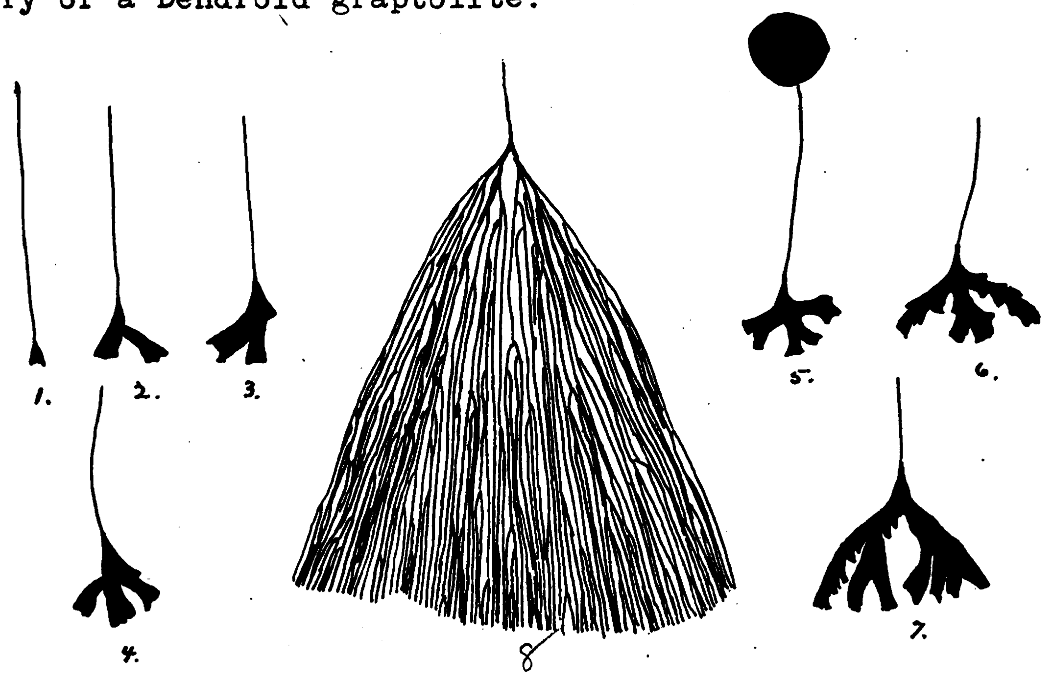
1. Order Dendroidea
2. Order Graptoloidea

Order Dendroidea

Graptolites of the order Dendroidea are fan or funnel shaped colonies formed of many branches radiating from a sicula. In some colonies the branches are connected by delicate transverse bars known as dissepiments.

Dendroid graptolites were attached to the sea bottom or to floats of their own making.

The figures below show the different stages in the life history of a Dendroid graptolite.



1. A sicula with its long nema. x5.
2. A similar sicula, fully grown and giving off a lateral theca. x5.

3-7. Youthful colonies, showing continued budding of the thecae and forking of the branches. x5. 5. shows a primary disk to which the colony was attached. The disk is seldom preserved.

8. The mature colony, life size.

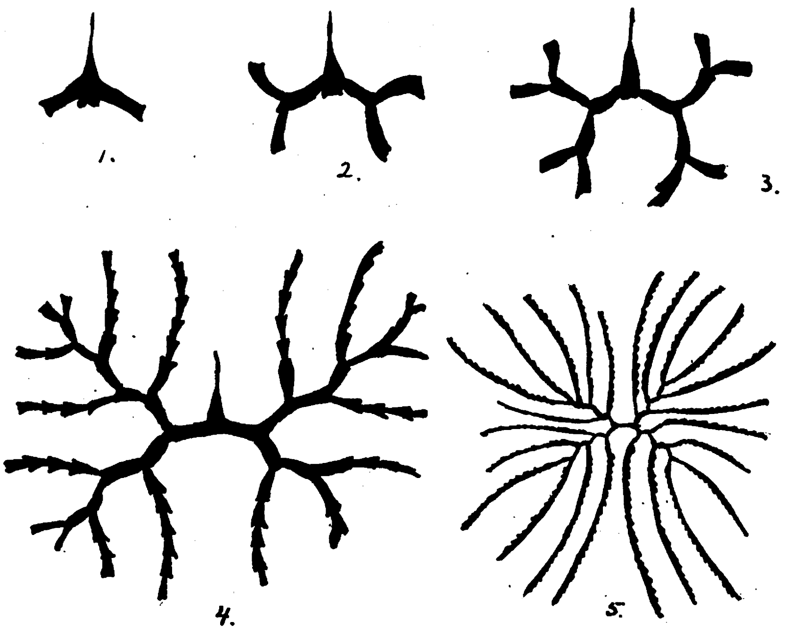
Order Graptoloidea

This order is divided into two suborders - suborder Axonolipa and suborder Axonophora.

Suborder Axonolipa

Graptolites of this suborder are derived from a single sicula. The thecae grow along one side of the branch (uniserial arrangement) or on both sides (biserial arrangement) with the openings of the thecae, the apertures, directed away from the sicula. The branches vary greatly in number.

Below are figures showing several stages in the development of an Axonolipa graptolite.



1. A young graptolite, showing the sicula, its nema, and the first two thecae. x5.
2-3. Youthful colonies, showing further budding and forking of the branches. x5.
4. An adolescent colony, fully branched. x5.
5. Mature colony, life size.

Suborder Axonophora

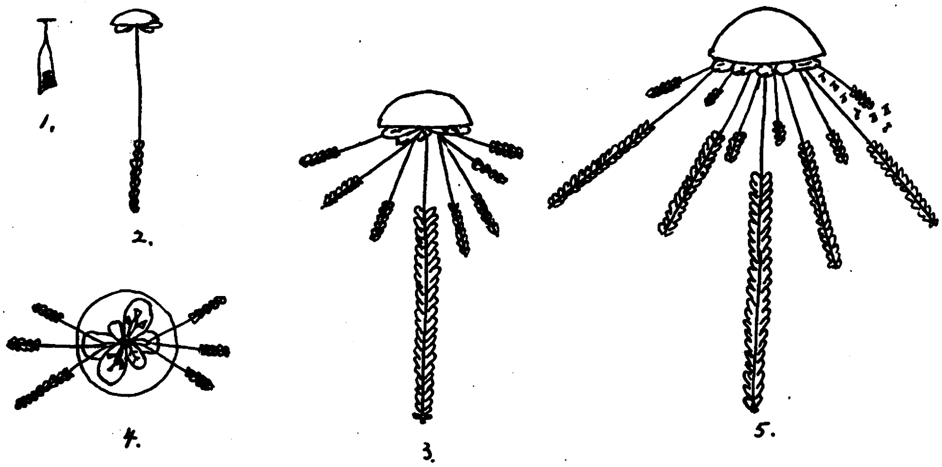
A graptolite of the Axonophora suborder consists of a number of branches, each developing from a separate sicula. Growth of the colony is begun by a single sicula attached by its tip to a small square, the node, in the center of a double plate. During later growth the plate becomes inflated to form a horny float, the basal cyst.

The thecae grow backwards along the nema, with the apertures pointing toward the attached end, in a direction opposite from that of the apertures in the Axonolipa graptolites. The upward growth of the thecae is accompanied by the continued increase in the length of the nema which carries the sicula farther away from the float. A stiff rod, the virgula, strengthens the nema.

From the node there grow out oval swellings, gonangia, in which siculae are developed. These siculae remain attached to the node, and grow, and form a cluster of branches around the primary branch. Cluster after cluster forms until a populous colony consisting of branches in various stages of growth develops.

The siculae formed in some of the gonangia do not remain attached to the node to grow into branches there, but develop small square plates of attachment at their tips, break away from the parent colony and float away to start new colonies.

The figures below show different stages in the life history of an Axonophora graptolite.



1. A sicula suspended by its node.
2. A somewhat older form, showing the float, gonangia budding around the node, and the double row of thecae of a primary branch suspended by the lengthening nema.
3. A more advanced colony showing the primary branch, secondary branches, and gonangia.
4. The same as 3., viewed from below. The undersurface of the float, gonangia surrounding the node, and several secondary branches may be seen.
5. A mature colony, showing the same features, and also the liberation of a generation of free-floating siculae.

(All the figures are enlarged.)

SPECIMENS ILLUSTRATING MAIN DIVISIONS OF GRAPTOZOA

The preservation of the graptolites on black shale makes the fossils very difficult to see. For this reason, throughout the exhibit to the right, drawings of complete specimens are used to aid in distinguishing the different structural features pointed out.

(The label for the Axonolipa suborder only is given to show the type label used. The other two are similar.)

Didymograptus sagitticaulus

The speciman and drawing above show the structure of a two branched, uniserial graptolite of the suborder Axonolipa.

Ordovician (Normanskill shale)
Mt. Moreno, New York 7409

The rare occurrences of graptolites in limestone, of which this is an example, have made possible a more exact knowledge of the structure of the animals.

The graptolites can be dissolved out from the rock and their original structure studied, for in the limestone they did not undergo the extreme flattening which occurred to those preserved in shale.

TRENDS IN THE DEVELOPMENT OF GRAPTOLITES

The order Axonolipa (See the above classification of graptozoa) comprised progressive types of graptolites which showed numerous changes following certain definite lines of development.

Two series of changes are illustrated in the exhibit to the right:

1. A change in the position of the branches from pendent to erect.
2. A simplification in branching.

1. Change in the position of the branches.

In the earliest graptolites the branches were pendent, hanging down from the end of the nema so that they were almost parallel with each other. Later graptolites showed an increase in the angle between the branches until it was 180° and the branches were horizontal. The term extensiform is applied to graptolites in which the branches are horizontal.

Intermediate forms with branches at angles between pendent and horizontal are termed declined.

In still later forms the branches turned back until they lay along the nema and formed an enclosing protection for it. Branches of this type are scandent.

Those graptolites in which the branches have turned back from the horizontal, but have not reached the scandent position are called reclined.

Position of the Branches

The graptolites used to Illustrate (carry out) the change in the position of the branches from pendent to erect are as follows:

Dependent:
- Didymograptus bifidus 7419 a.
- Tetragraptus pendens 7416

Declined:
- Didymograptus serratulus 7460

Extensiform:
- Didymograptus patulus 16492
- Tetragraptus quadribrachiatus 7405

Reclined:
- Tetragraptus similis 7402
- Didymograptus (Isograptus) gibberulus 16491
- Dicellograptus sextans 7410

Scandent:
- Phyllograptus ilicifolius 13030

2. Simplification in branching

The second line of development in the graptolites was in the reduction of the number of branches. The earliest types of graptolites had numerous branches, sometimes as many as thirty-two. These many branched forms were gradually replaced by graptolites with fewer branches until a graptolite with one branch (Monograptus) was attained.

The two trends in graptolite development - the change in the position of the branches and the simplification in branching, took place at the same time.

The fossils used to illustrate the simplification in the branching of graptolites are given below:

Specimen 7407
- d. Goniograptus thureaui
- b. Tetragraptus pendens
- e. Didymograptus niditus

Monograptus Clintonensis 8848

<u>Exhibit: Dependence of Animals as Shown in Paleontolgy</u>

The subject of the association of animals of different species, with the varying degrees of dependence from commensalism to parasitism, is an interesting one to trace among living animals.

The original intention for the exhibit was to illustrate these different types of modern associations with fossil examples, pointing out the fact that dependence in animals is a principle of very ancient origin.

When the material available was examined it was found that it was not only limited in extent, but that it all illustrated one type of association - commensalism. It has therefore, all been presented under that one heading and the parallelism with living animals is not as close as was expected.

Mobility and independence are two functions of animals which in general distnguishes them from members of the plant kingdom, which are attached in habit. There are animals which have for at least part of their life cycles lost these two distinguishing features.

Some animals have become attached and fixed in growth habits, as may be seen in other exhibits on this floor. They include the barnacles, corals, and others.

Other animals have by adaptations in growth habits lost an independent free mode of life and become dependent upon other animals for their existence. The degree to which this dependence has gone varies from a casual association to absolute dependence. Three distinct types of such association are recognized: commensalism (or mutualism), symbiosis, and parasitism. These classifications are used only for animals of different species, not for the communal life of animals of the same species.

The word commensalism is derived from two words meaning "to eat at the same table" and denotes a relationship from which neither partner apparently derives any advantages.

Symbiosis is the living together of animals which results in mutual benefits to each.

An association in which one member receives all the benefits at the expense of the other is termed parasitism. The parasite may take so much from its "host" that the host may be injured or even killed.

There are no occurences of dependent associations in the earliest faunas. Pre-Cambrian and Cambrian faunas contain only freely moving independent animals. Considerable time elapsed before organic combinations were developed.

Stromatoporoid with Coral

Stromatoporoids resemble corals, grwoing in large nodular or reef-like masses which during Paleozoic times attained considerable size. In structure they are formed of many concentric wavy layers of lime (the laminae), separated by tiny rods.

Commensal corals were frequently associated with stromatoporoids. The erect corals tubes were surrounded by the stromatoporoid mass as it grew up around them.

The block shows the compact nature of the stromatoporoid over-growing a tube coral.

In the enlargement ofa section from the block, the tube walls of the coral can be distinuished from the laminae of the stromatoporoid.

Coral with Commensal Worm

The young *Pleurodictyum stylopora* coral at the end of its free swimming larval stage attached itself in many cases to a particular snail (gastropod) shell, that of *Loxonema hamiltoniae*. There it developed into the adult fixed form. This species is not found attached to gastropods other than *Loxonema*.

A commensal worm *Hicetes* often grew with the coral. Apparently both the small worm and the young coral became attached at nearly the same time. The tube in which the worm lived was built through several convolutions, then straight up as the coral grew out around it and increased in size.

Usually the growth of the worm tube kept pace with that of the coral so that the ends of the tube remained on the tentacular surface of the coral. The openings of the round worm tubes can be distinguished from the angular outlines of the coral cells.

1. Cast of the gastropod *Loxonema hamiltoniae* upom which the coral *Pleurodictyum* often grew.
2. The under side of a corallum with the impression of the gastropod *Loxonema* to which it was attached.
3. The top of a corallum showing the openings of the worm tube.
4. The form of an entire worm tube of *Hicetes* within the coral.

Gastropods (Snails) on Crinoids

The association of gastropod (snail) and crinoid began in the Ordovician Period and continued until the Carboniferous Period.

The gastropod settled on the upper surface of the crinoid, within the circle of the arms, with its shell covering the anal opening. In this position it could utilize the waste materials from the crinoid.

In the earliest example of the association - Cyclomema bilix upon the crinoid Glyptocrinus decadactylus - the gastropod was not fixed upon the crinoid and was free to come and go at will.

Later associations seem to show that such a combination had become a fixed habit, and that a definite adaptation for a dependent mode of life had developed. In all cases certain gastropods are found only associated with certain crinoids, showing that it was not a random choosing of a convenient sourde of food supply on the part of the gastropod. From all the crinoids living in its locality, definite choice was made of that crinoid for which a dependent adaptation had been developed.

Exhibit: Adaptive Modifications of Crinoid and Cystid Stems.

This exhibit is arranged to correct the common idea that all crinoids and cystids are stalked and rooted throughout adult life, and present examples of these animals which have by changes in the stem structure become adapted to different modes of life.

Crinoids and cystids are placed in the classification of Echinoderms under the division Pelmatozoa which contains those types ~~which are~~ having a stalked or fixed ~~in~~ growth habit. All the members of this division do not retain a fixed condition for their entire lives.

There are many modifications among fossil crinoids and cystids which show that although the stalked forms were predominant, life-long fixation was not universal.

Some Pelmatozoa possessed no stem or other means of attachment, so necessarily followed a free swimming or floating existence. In others the stems tapered to points which could not be used for permanent attachment, but could furnish a temporary anchorage. In still others the ends of the stems were modified to form floats or drags.

The crinoids and cystids in this exhibit show that animals of one group may by modifications of certain structures become adapted to different modes of life. There are free swimming and passively floating types, bottom crawling and attached forms - all of the one division, Pelmatozoa.

Eucalyptocrinus

Eucalyptocrinus has the growth of a typical stalked crinoid. The branching roots fixed the animal securely to the mud of a soft sea bottom.

Crinoids growing in seas with hard bottoms in which a root growth would not be possible, were fixed in place by an enlargement of the end of the stem which formed a flat-bottomed encrustation cemented to other objects.

In the specimen above, of which the cementing base alone is left, the crinoid was attached to a coral (Favosites).

Poteriocrinus sp.

The stem of the crinoid Poteriocrinus tapered out to a point and was not used for permanent fixation. It was flexible and pliant and could be coiled under some fixed object to give the crinoid a temporary means of attachment.

Pleurocystites squamosus

This cystid was never firmly rooted to one spot, but anchored itself temporarily by hooking the flexible end of its stem about some fixed object.

The animal did not grow erect in the water. It lay prostrate on the sea bottom moving probably by beating the water with its two arms.

Camarocrinus

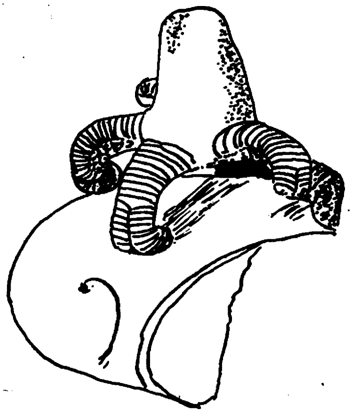
For a long time there was doubt as to the exact nature of Camarocrinus. It is known now that it is the enlarged bulbous end of the stem of the crinoid Scyphocrinus. The bulb formed a float for the crinoid in its drifting, floating existence.

Ancyrocrinus

The free lower end of the stalk of the crinoid Ancyrocrinus is enlarged and bears four hook-like projections which formed a drag and ballast for the crinoid.

In quiet waters the weight served to steady the animal; in a current the activity of the drag controlled the motion of the crinoid.

Edriocrinus sacculus



The young Edriocrinus was attached to objects directly by its base. When fully grown the crinoid broke away from its place of attachment and had a free existence, crawling around on the sea bottom by means of its short, stout arms.

Uintacrinus socialis

The crinoid Uintacrinus had no stem or other means of attachment, but floated freely about with its arms hanging pendent, The arms were extremely long, reaching the length of four feet in adult forms.

Uintacrinus is often preserved in groups of many individuals. It is believed that the animals came together in swarms during the breeding season, the long arms of many became entangled, and they were smothered by the crowding. Their bodies sank to the bottom and were preserved as a large mass of crinoid bodies and arms.

A big slab of rock in another exhibit case in the hall shows one of these masses of bodies of Uintacrinus.

large

Exhibit: The Development of Cephalopods

The development of the cephalopods is presented in two parts - (1.) to illustrate the closerecoiling in the shell of the nautiloidea, from the early straight type to the final involute form; and (2.) to illustrate the growing complexity of the suture lines in the ammonoidea through the stagesoof goniatitic, ceratitic, to ammonitic.

The fossils used to carry out the first part include:

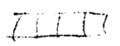
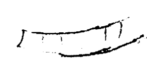
1. Orthoceras 
2. Cyrtoceras (Meloceras) elongatum 2416 
3. Ryticeras 3653 
4. Gigantoceras elrodi 3655 
5. Temnocheilus forbesiaranus 2862 
6. Nautilus 

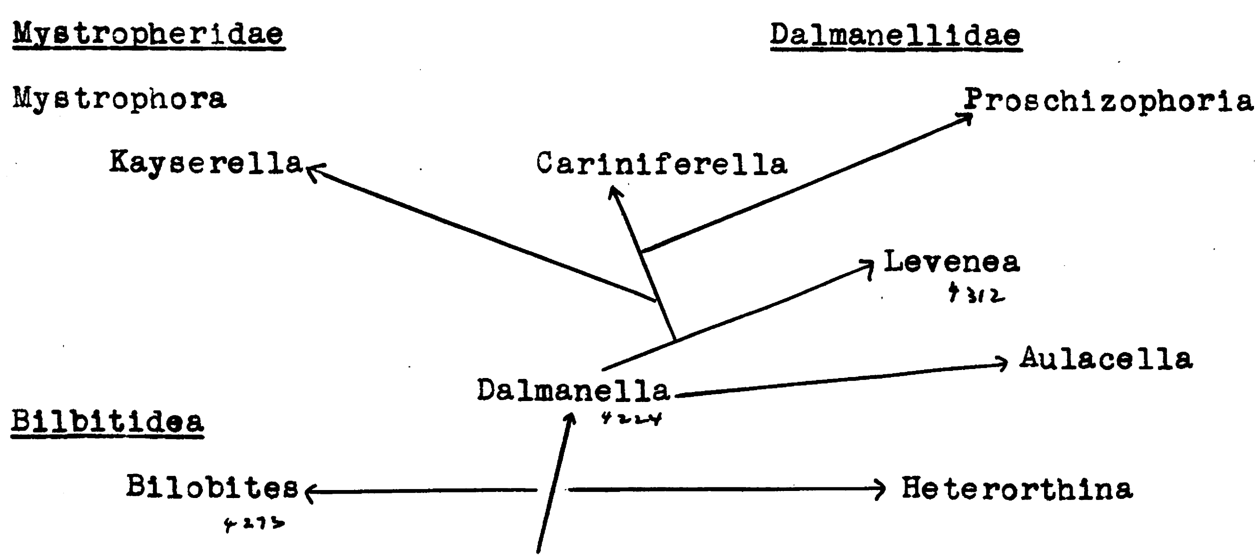
Exhibit: The Relationships of Certain Brachiopod Genera

Schuchert andCooper in their "Brachiopod Genera of the Suborders Orthoidea and Pentameroidea", have presented the interrelationships by means of charts. This idea is to be followed in this exhibit and representative species of each genera mounted on charts with arrows indicating the genus from which they arose and the genera developing from them.

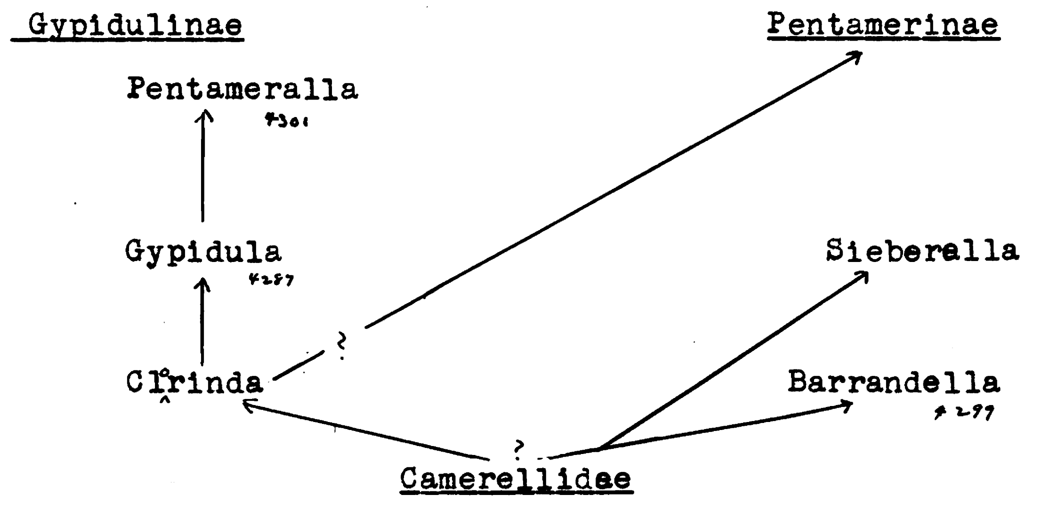
At present a great number of genera have no fossil representatives, but it is hoped that more can be added.

Below are given two examples of the type of arrangement which the charts are to follow.

Families of the Superfamily Dalmanellacea



Genera of the Subfamily Gypidulinea



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