Paleontology

Unit.4

Phylum Echinodermata

Morphology

Echinoderms have been compared to living, moving castles. Castles are made of interlocking blocks, with a single main entrance and numerous slit windows for air and for defense. Echinoderm skeletons are made up of interlocking calcium carbonate plates and spines. This skeleton is enclosed by the epidermis and is thus an endoskeleton. In some, such as sea urchins, the plates fit together tightly. In others, such as starfish, the plates are more loosely bound, and in sea cucumbers the plates are usually microscopic. But whatever their shape, the plates of echinoderms have a very typical microstructure: electron microscopy reveals them to be, not solid blocks, but fine networks of calcium carbonate forming a structure known as **stereom**. Each skeletal element of an echinoderm is actually a single crystal of calcium carbonate, very finely branched and structured.

Between the skeletal plates, a number of special structures protrude, with which the echinoderm breathes, moves, and defends itself. Typically, these are tube feet, pedicellaria, and gills. All echinoderms have a **water-vascular system**, a set of water-filled canals branching from a ring canal that encircles the gut. The canals lead to **podia**, or tube feet, which are sucker-like appendages that the echinoderm can use to move, grip the substrate, or manipulate objects. These tube feet are extended and retracted by hydraulic pressure in the water-vascular system. **Pedicellaria** are small, snapper-like skeletal elements that are used by the echinoderm to keep small organisms from settling on its body.

Classification

The phylum echinoderms is divided into five extant classes: Asteroidea (sea stars), Ophiuroidea (brittle stars), Echinoidea (sea urchins and sand dollars), Crinoidea (sea lilies or feather stars), and Holothuroidea (sea cucumbers).

The most well-known echinoderms are members of class Asteroidea, or sea stars. They come in a large variety of shapes, colors, and sizes, with more than 1,800 species known so far. The key characteristic of sea stars that distinguishes them from other echinoderm classes includes thick arms (ambulacra; singular: ambulacrum) that extend from a central disk where organs penetrate into the arms. Sea stars use their tube feet not only for gripping surfaces, but also for grasping prey. Sea stars have two stomachs, one of which can protrude through their mouths and secrete digestive juices into or onto prey, even before ingestion. This process can essentially liquefy the prey, making digestion easier.

Brittle stars belong to the class Ophiuroidea. Unlike sea stars, which have plump arms, brittle stars have long, thin arms that are sharply demarcated from the central disk. Brittle stars move by lashing out their arms or wrapping them around objects and pulling themselves forward. Of all echinoderms, the Ophiuroidea may have the strongest tendency toward 5-segment radial (pentaradial) symmetry. Ophiuroids are generally scavengers or detritivores. Small organic particles are moved into the mouth by the tube feet. Ophiuroids may also prey on small crustaceans or worms. Some brittle stars, such as the six-armed members of the family Ophiactidae, are fissiparous (divide though fission), with the disk splitting in half. Regrowth of both the lost part of the disk and the arms occur, yielding an animal with three large arms and three small arms during the period of growth.

Sea urchins and sand dollars are examples of Echinoidea. These echinoderms do not have arms, but are hemispherical or flattened with five rows of tube feet that help them in slow movement; tube feet are extruded through pores of a continuous internal shell called a test. Like other echinoderms, sea urchins are bilaterans. Their early larvae have bilateral symmetry, but they develop fivefold symmetry as they mature. This is most apparent in the “regular” sea urchins, which have roughly spherical bodies, with five equally-sized parts radiating out from their central axes. Several sea urchins, however, including the sand dollars, are oval in shape, with distinct front and rear ends, giving them a degree of bilateral symmetry. In these urchins, the upper surface of the body is slightly domed, but the underside is flat, while the sides are devoid of tube feet. This “irregular” body form has evolved to allow the animals to burrow through sand or other soft materials.

Sea cucumbers of class Holothuroidea are extended in the oral-aboral axis and have five rows of tube feet. These are the only echinoderms that demonstrate “functional” bilateral symmetry as adults because the uniquely-extended oral-aboral axis compels the animal to lie horizontally rather than stand vertically.

Like all echinoderms, sea cucumbers have an endoskeleton just below the skin: calcified structures that are usually reduced to isolated microscopic ossicles joined by connective tissue. In some species these can sometimes be enlarged to flattened plates, forming armor. In pelagic species, such as Pelagothuria natatrix, the skeleton and a calcareous ring are absent.

Geology and stratigraphy

Echinoderms belong to the phylum Echinodermata having 5 classes namely Crinoidea (Sea lilies and Feather stars), Ophiuroidea (Brittle stars and basket stars), Asteroidea (Sea stars), Echinoidea (Sea urchins) and Holothuoidea (Sea cucumbers) (Fig. 8.11). They are benthic and found in all depth of the oceans around the world. They are good scavengers in bottom and grazing on various micro and macro algae, corals etc. Some of the members like crown of thorn starfish *Acanthaster planci* (Linneaus, 1758) known to graze corals in large numbers create local coral bleaching and destruction of coral reefs. Some of the species belong to class Holothuroidea (sea cucumbers) are used as food as well as medicine. All the five classes of organisms are found distributed in Andaman and Nicobar Islands surrounding marine environments (Table 8.4). In total 777 echinoderm species were reported from India. Many species are found associated with coral reefs, sea grass meadows and seaweed beds. As per the status and distribution of Echinoderms in reef communities of Nicobar Islands, 75 species belonging to 42 genera, 24 families and 12 orders were reported (Koushik et al., 2013). The Ophiuroid diversity was reported to be higher in Nancowry Island and minimum in Car Nicobar Island. The species of Echinoderm include *Holothuria atra*, *Stichopus chloronotus*, Ophiocoma *erinaceus*, *Ophiothris pussila* along with *Comatula pectinata* as most dominant in Nancowry Islands.

Echinoderms possess compound skeletons, which disintegrate very rapidly after death. Their skeletal fragments form a significant proportion of many Paleozoic rocks, especially limestones. To be preserved intact or nearly so, echinoderms must be buried immediately after death without any subsequent disturbance. Indeed many of the best-preserved primitive echinoderms seem to have been buried alive. Important taxonomic and evolutionary consequences arise from the type of fossil record of primitive echinoderms. Conversely, because all echinoderm classes, and many lower taxa, appear abruptly in the fossil record, construction of a phylogenetic tree for the phylum is very difficult. In term of numbers of skeletal parts, they have the most complex morphology of any phylum and they are second only to the vertebrates in the intimacy of the relationship between soft and hard anatomy. Of respiratory structures, all rhombs, hydrospires, epispires, and the cataspires of parablastoids grew at plate margins.

Blastoids and Crinoids

Morphology

Echinoderms are an extremely diverse group of advanced invertebrates including such familiar forms as starfish, sand dollars, urchins, and sea cucumbers. The name echinoderm means "spiny skin." Apart from their spiny skin, all echinoderms are united in exhibiting five-fold (pentameral) symmetry. There are a large number of classes of echinoderms, many of which have good fossil records. In this lab, however, we will focus only on the crinoids and blastoids because of their abundance in Upper Paleozoic rocks. These stalked echinoderms were so pervasive during the Mississippian and Pennsylvanian periods, that their remains make up the dominant particles in many bioclastic limestone deposits.

Crinoids and blastoids both share a common overall morphology consisting of a calyx (or "head"), stem, and holdfast (or "root") (Figure 1). The stem is made up of a stack of disc-shaped elements called columnals. The calyx Figure 1. Restoration of a crinoid. 10–2 consists of a number of polygonal plates, with arms typically extending upward for filtering nutrients from sea water. All crinoids possess five arms attached to the calyx . The arms typically split into a much larger number of smaller branches. Upon death of an individual, the plates making up the calyx and arms usually disarticulate to become isolated sedimentary particles. Preservation of intact specimens is uncommon.

Blastoids possess a large number of small erect arms in life, but the arms are almost never preserved in fossil specimens. Rather, the calyx of a fossil blastoid is distinguished by its very obvious pentameral symmetry and the presence of 13 plates. There are three basal plates, five radial plates, and five deltoid plates. A feeding structure called the ambulacrum is positioned within each radial plate. The mouth and anus are located at the top of the calyx, with the anus being the largest of the five pores

Classification

Five major morphological groups of Crinoidea were recognized in the "Treatise".

The fundamental division of Crinoidea has been based upon a combination of characters such as the number of plate circlets in the cup, the rigidity with which they are sutured together, the presence and position of any additional plates within these circlets, the structure of the oral surface and the structure of the arms.

Four distinct groups occured only during the Paleozoic:

Camerata:
- tegmen chamber above the cup
- rigidly sutured cup,
- heaviliy plated, rigid tegmen,
- subtegminal mouth

Disparida:
- unequal size of cup plates
- arms free above the cup
- two-circlet (monocyclic) cup
- cone/barrel-shaped cup

Cladida:
- richly branched arms structure
- arms free above the cup
- three-circlet (dicyclic) cup
- prominent anal sac
- few or no oral plates

Flexibilia:
- weakly united calyx plates
- three-circlet (dicycylic) cup
- reduced infrabasals
- reduced anal plates
- no rigid tegmen, exposed mouth
- uniserial arms without pinnulae
- brachials with flanges

A fifth group, the Articiulata, were present after the Palaeozoic. They all have pinnulate arms and a cup lacking any anal plates. Tey are characterized by the predominantly biserial arrangement of the arms.

Blastoids are assumed to have evolved from the Cystoids. Blastoids are subdivided into two orders: Fissiculata, which are characterized by direct entrance to the individual hydrospires by way of slits; and Spiraculata, which are characterized by indirect entrance to the hydrospires through canals by way of pores; the earliest blastoid yet found, *Macurdablastus* from the Middle Ordovician of Tennessee, cannot be classified as either order.

<u>Geology and stratigraphy</u>

Blastoid (blas'-toyd) **fossils** commonly are called "sea buds." They are closely related to crinoids but differed in that, instead of arms, blastoids had long hair-like brachioles that swept food into the mouth. The delicate brachioles rarely were preserved.

Like crinoids, blastoids had a mouth at the top of the body (calyx) surrounded by small round holes that conducted food particles into and wastes out of the body.

The oldest blastoids, found in **Silurian** rocks, lived about 425 million years ago. The animals survived until the **Permian** Period, about 260 million years ago, when they became extinct.

Blastoids are beautiful fossils that look much like small hickory nuts. They most commonly are found in the river cliffs and stream banks of western and southwestern Illinois, especially in Randolph County, and in southern Crinoids are an ancient fossil group that first appeared in the seas of the Middle Cambrian, about 300 million years before dinosaurs. They flourished in the Palaeozoic and Mesozoic, and some survive to the present day. Although sometimes different in appearance from their fossil ancestors, living forms provide clues about how fossil crinoids must have lived.Illinois near the Ohio River.

Crinoids originated in the Cambrian Period and still exist today, although their golden age was in the Late Paleozoic. Blastoids originated in the Ordovician Period and became extinct at the end of the Permian Period.

Phylum Arthropoda

Morphology

Morphologically, arthropods have segmented bodies, including jointed appendages, and are covered with a chitinous cuticle that serves as an exoskeleton. Arthropods must undergo periodic molts as growth and development proceeds. Sexes are separate. Morphological differences between sexes are few in some species, marked in others.

Parasitic arthropods are usually small, ranging from microscopic to 1-2 cm in length. Body segments may be grouped into discrete regions, such as the head, thorax and abdomen of insects, or show various degrees of fusion. In some cases, segmentation has been reduced to the extent that the organism is barely recognizable as an arthropod. The body surface is covered in a series of plates. Each of these plates, and the separate segments of each jointed appendage (including the mouthparts), have their own names. Fortunately, the terminology is relatively consistent within each of the arthropod classes.

The digestive system is complete. The mouth is surrounded with jointed mouthparts that gather (possibly through piercing or biting) and manipulate food. The gut is usually divided into a foregut, midgut, and hindgut. The circulatory system is open; blood is pumped by a heart and circulates through the body cavity. The nervous system is well developed, usually including eyes, antennae and other sensory structures.

Classification

Arthropods can be grouped into several subphyla, with each of these subphyla then divided into different classes. In this lesson we will examine how arthropods are divided into these subphyla, and then we will consider the details of one well-known subphylum: Crustacea. We will also take a look at one of the arthropod classes that contains many feared and reviled species: the arachnids.

The sheer number of arthropod species (over one million and growing!) presents a substantial challenge for scientists trying to subdivide them into distinct groups based on their evolutionary relatedness. Just to give you an idea of some of the conflicts that exist in the field of arthropod systematics, some scientists have suggested (based on molecular data) that some species within the group Crustacea are actually more closely related to insects (in the group Hexapoda) than they are to other crustacean species. This is currently a controversial topic, and in this lesson we will consider the established, traditional groupings of arthropods. In this classification, arthropods are divided into five subphyla:

1. Trilobitomorpha (Trilobites).
2. Chelicerata.
3. Crustacea.
4. Myriapoda.
5. Hexapoda.

Class Trilobita (lower Cambrian through Permian)
Trilobites were present on earth for 350 million years. During this period, over 4000 species have been identified, with very little change or adaptation from their original appearance. Trilobites are named for three longitudinal lobes of their bodies. The body is also divided into three parts: the head (cephalon), thorax, and tail (pygidium).

Class Ostracoda (Cambrian to Recent)
They are commonly called the seed shrimp, and are represented by microscopic crustaceans. The head has two antennae, the thorax has one to three pairs of appendages. The body is enclosed by a bivalved shell.

Class Branchiopoda (lower Devonian to Recent)
This class of crustaceans is small (1/8") in size, and may have a dorsal shield or a bivalved shell. They have ten to thirty-two trunk segments, all with paired appendages.

Class Cirripedia (Silurian to Recent)
This class of Arthropoda is represented by the barnacles. Barnacles live cemented to a fixed object with a mantle enclosing the body. The animal secretes a calcareous shell.

Class Malacostraca (Cambrian to Recent)
Shrimp, lobsters, and crabs represent this class. Most are marine, but some are fresh water animals. All have eight segments in the thorax, with a shield that covers the head and thorax. Most have compound eyes.

Class Merostomata (Ordovician to Recent)
Spiders and scorpions represent the living members of this class. Their bodies are composed of a combined head and thorax region with an abdomen. They have no antennae, and the front pair of appendages is modified for feeding or poison-injecting fangs. Eurypterids are extinct animals in that class, closely related to the horseshoe crab. Some grew up to nine feet in length. Their head had two sets of eyes, and they had four pairs of walking legs.

Class Insecta (Devonian to Recent)
Insects are the largest class of arthropods, with over 900,000 species known. They are similar to other arthropods, except that they generally have wings. Insects' body parts are: head, thorax, abdomen, one pair of antennae, three pairs of legs, and one or two pairs of wings. Fossilized insects are rare due to their exoskeleton being so thin and soft.

Geology and stratigraphy

They are important members of marine, freshwater, land and air ecosystems, and are one of only two major animal groups that have adapted to life in dry environments; the other is amniotes, whose living members are reptiles, birds and mammals.[13] One arthropod sub-group, insects, is the most species-rich member of all ecological guilds in land and freshwater environments.[12] The lightest insects weigh less than 25 micrograms (millionths of a gram),[14] while the heaviest weigh over 70 grams (2.5 oz).[15] Some living crustaceans are much larger; for example, the legs of the Japanese spider crab may span up to 4 metres (13 ft),[14] with the heaviest of all living arthropods being the American lobster, topping out at over 20 kg (44 lbs).

Class Trilobita	(lower Cambrian through Permian)
Class Ostracoda	(Cambrian to Recent)
Class Branchiopoda	(lower Devonian to Recent)
Class Cirripedia	(Silurian to Recent)
Class Malacostraca	(Cambrian to Recent)
Class Merostomata	(Ordovician to Recent)
Class Insecta	(Devonian to Recent)

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