

Lecture 5

PHYLUM ECHINODERMATA (starfish, sea urchins, sand dollars, crinoids, blastoids)

Name: Echinodermata means "spiny" (echinos) + "skin" (derma).

Chief characteristics: Calcite skeleton with five-part symmetry.

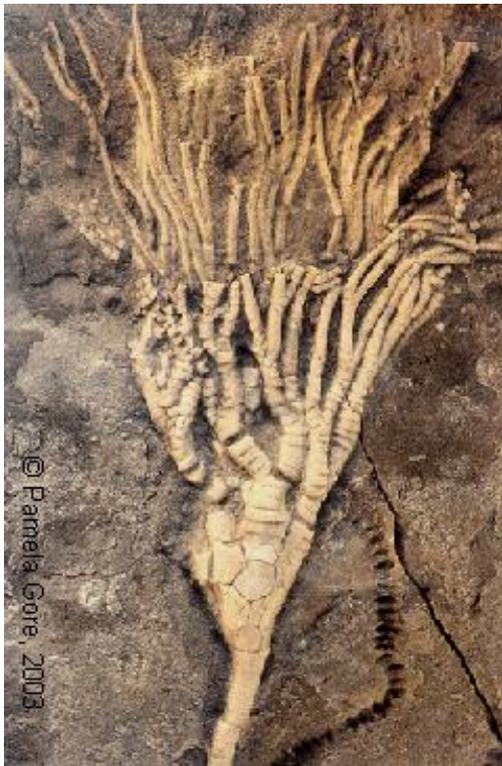
Geologic range: Cambrian to Recent.

Mode of life: Exclusively marine. Some are attached to the sea floor by a stem with roots; others are free-moving bottom dwellers.

A. CLASS CRINOIDEA (crinoids or "sea lilies")

Crinoids are animals which resemble flowers - they consist of a calyx with arms, which is attached to the sea floor by a stem of calcite disks called columnals. Some living crinoids are swimmers, and not attached.

Geologic range: Ordovician to Recent.



Crinoids



Fossil crinoid stems

B. CLASS BLASTOIDEA (blastoids)

Blastoids are extinct animals with an armless bud-like calyx on a stem.
Geologic range: Ordovician to Permian - all extinct.



Fossil blastoids. Image courtesy of [Paleontological Research Institution](http://www.paleontologicalresearchinstitute.com)

C. CLASS ASTEROIDEA (starfish)

Starfish are star-shaped echinoderms with five arms.
Geologic range: Ordovician to Recent.



Modern starfish.

D. CLASS ECHINOIDEA (sand dollars and sea urchins)

Echinoids are disk-shaped, biscuit-shaped, or globular. Viewed from above, they may be circular or somewhat irregular in shape, but with a five-part symmetry.

Geologic range: Ordovician to Recent.



Modern echinoid with spines attached.



Modern sand dollar with its tiny spines still attached.

ECHINODERMATA

CLASS ECHINOIDEA

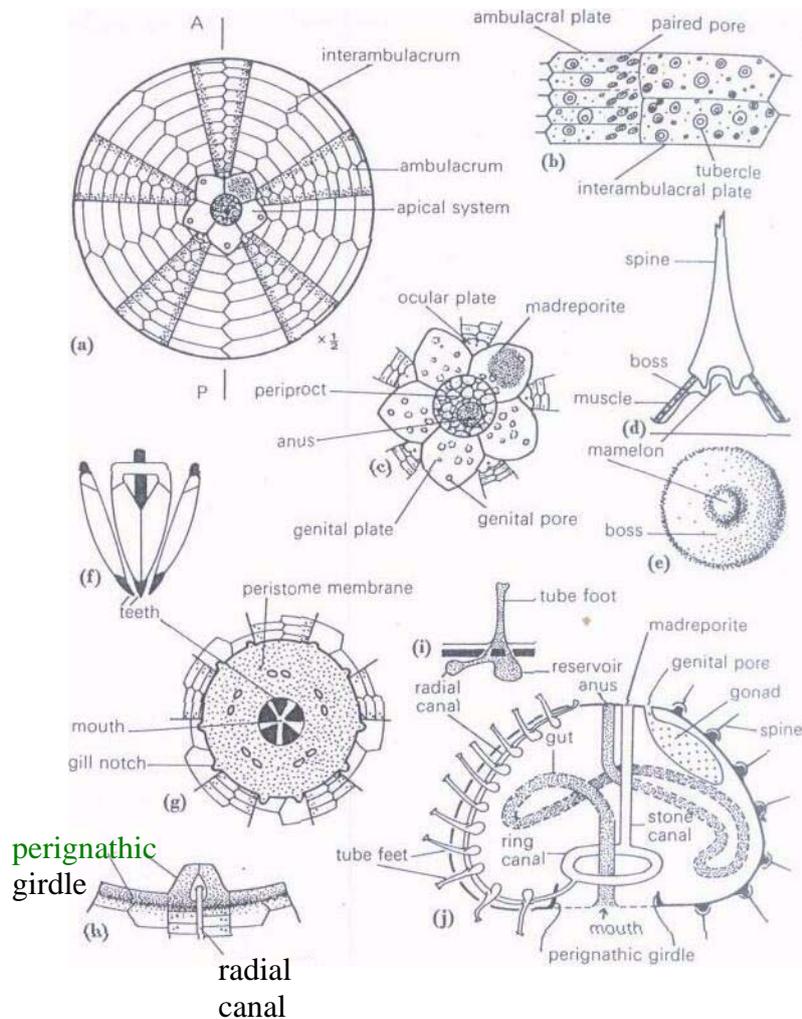
Morphology

The test of a typical echinoid is hemispherical in shape. It consists of many interlocking plates, arranged in 10 double columns, which radiate from the apex of the upper surface to the mouth in the centre of the lower surface. Five of these columns carry tube feet and are known as **AMBULACRA**. The other five, with no tube feet, are known as **INTER-AMBULACRA**. The 10 columns together make up the **CORONA**. Situated at the apex of the test is the **APICAL SYSTEM** consisting of about 10 small plates which are connected with specialised functions, and one of which is the **MADREPORITE**. The central part of the apical system consists of a membrane, the **PERIPROCT**, which surrounds the anus. In the centre of the lower surface of the test is a similar membrane, the **PERISTOME**, which surrounds the mouth. Most of the surface

of the test is covered by SPINES which are attached to TUBERCLES.

SOFT BODY. The test is filled with fluid in which the rather insubstantial soft organs are suspended (fig.61j), the gut being looped around inside the body wall as it ascends from mouth to anus. The radial canals of the water vascular system underlie the ambulacral areas, and the tube feet penetrate through paired PORES in the ambulacral plates to the exterior. These tube feet, typically, end in suckered discs, with which the echinoid can cling to a firm surface. In use, the tube foot is extended by water forced into it from a reservoir (fig.61i) and exerts a suction grip on an object which it touches, by the withdrawal of water. In this way the tube feet may be used either for clinging or in locomotion. In some echinoids, they may also be modified for other functions which may be sensory, for use in feeding, for the construction of burrows, or they may form leaf-like respiratory structures. Some forms carry gills, which occur as bushy outgrowths around the peristome. There are five gonads and their products are discharged through pores in five plates (genital plates) of the apical system. The outside of the test is covered by skin, and the spines are held in position, and moved, by muscles which are attached to the outer side of the plates of the test. The plates have a network structure with microscopic pores which are permeated with soft tissue. After the death of the animal all the soft body decays and, during fossilization, the minute pores are normally closed by precipitation of calcite. Since each plate and spine is a single crystal of calcite, these will show the characteristic calcite cleavage when the fossil is broken.

ORIENTATION. When viewed from the upper surface, the outline of the type of echinoid test just described is a circle, with the apical system at its centre, and the double columns of plates forming radii (fig.61a). The ambulacra are said to be RADIAL in position, since each overlies a radial canal of the water vascular system (fig. 6 1j) and the interambulacra are said to be INTER-RADIAL. The only asymmetric feature in the radial symmetry of this test is the position of the madreporite, and this is used to define the ANTERIOR-POSTERIOR orientation. The test is



61 Morphology of a regular echinoid, based mainly on *Echinus*. a, aboral view (A, anterior; P, posterior; line A-P, plane of symmetry), b, ambulacral and interambulacral plates; enlarged, c, view of apical system, enlarged, d, section through a tubercle and spine, e, plan of a tubercle. f, side view of the jaws showing a part of the complex of plates which holds the five teeth (shaded black), g, oral view showing the peristome membrane (stippled) surrounding the mouth, h; a part of the perignathic girdle as seen from inside the test. i, a section through a tube foot to show its relationship with the paired pores of an ambulacral plate (thick black line). j» a simplified section through an echinoid test to show the arrangement of the internal organs (on the left the section cuts an ambulacrum and on the right it cuts an interambulacrum).

conventionally aligned as shown in fig. 61a, c, with the madreporite on the right, towards the anterior end. The lower surface, on which the mouth lies, is the ORAL surface; and the upper surface is the A B O R A L surface. TEST. The pattern of symmetry shown by the test is a convenient basis for separating the echinoids into two groups, REGULAR forms, in which the coronal plates show RADIAL symmetry (fig.61a), and IRREGULAR forms, in which the five rays are arranged with BILATERAL symmetry. In regular forms the anus (surrounded by the periproct) lies WITHIN the apical system (fig.61a), and the mouth is at the centre of the oral surface and contains jaws. In irregular forms, the anus lies

OUTSIDE the apical system in the POSTERIOR **interambulacrum**, and the mouth may lie either in the centre of the oral surface and have jaws, or towards the anterior margin and lack jaws.

The plates of the apical system and of the corona may be preserved intact in a fossil **echinoid**.

The positions of the **periproct** and the **peri-stome**, however, are usually indicated by a space.

APICAL SYSTEM. In regular **echinoids** (fig.61c), the apical system contains 10 plates, arranged in one or two rings around the periproct. Five of these, the OCULAR plates, are situated radially; and alternating with them are five **inter-radial** GENITAL plates. The ocular plates each bear a pore through which passes the terminal tentacle of the radial water vessel. The genital plates are the larger and each has a pore through which eggs or sperms are discharged. One genital plate (the right anterior) is also the **MADREPORITE** and is finely perforated. In irregular echinoids, the apical system does not enclose the periproct and it is small and compact; it may contain less than five genital plates, but always has five oculars.

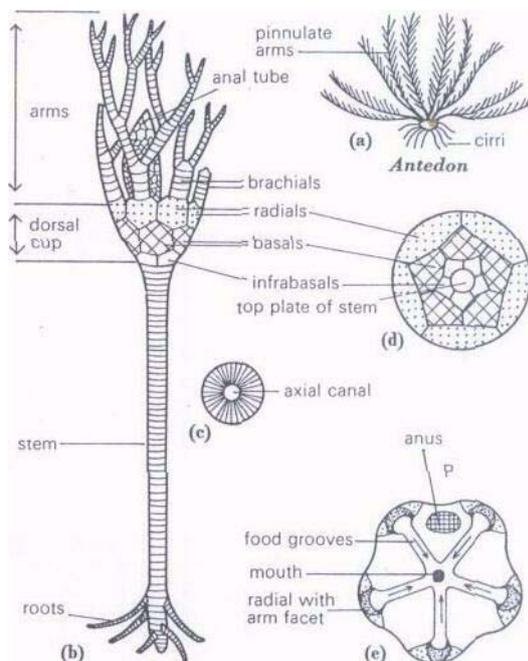
Class Crinoidea

Morphology

In living crinoids, the bulk of the soft body is contained in the calyx. This consists of two parts, the DORSAL CUP, covered on the oral side by a plated membrane, the **TEGMEN**. The arms articulate freely with the calyx. In many genera they branch, and each branch may bear two rows of small **branchlets**, PINNULES. Together they form an open 'funnel' around the mouth and each bears a ciliated food-groove, (**AMBULACRUM**), on its oral side, lined with tube feet which trap food (falling plankton) in mucus. The food is swept by ciliary action down the food-grooves to the mouth. The stem may be quite short, or many feet in length. It may be anchored in sediment by 'rootlets' diverging from its base; or it may have prehensile branches (cirri) with which the **crinoid** clings to seaweed.

SKELETON. The plates of the **crinoid** skeleton are disposed in three main regions, the CALYX, ARMS and STEM (fig. 78b). The calyx may be a relatively flexible structure, but in many fossil genera the plates were united to form a rigid cup or box. The individual plates are usually hexagonal or pentagonal in shape, and are arranged symmetrically in circlets.

The DORSAL CUP (on the **aboral** side of the calyx) consists of two circlets of five plates, the **BASALS** below, and the **RADIALS** above. In some forms an extra ring of five plates, the **INFRABASALS**, is intercalated between the **basals** and the stem (fig.78b). In certain **crinoids** the dorsal cup contains additional plates; for instance, there may be **INTERRADIAL** plates intercalated between the **radials**; or in, some cases, the lowest arm plates, **BRACHIALS**, may be incorporated in the cup (fig.79a).



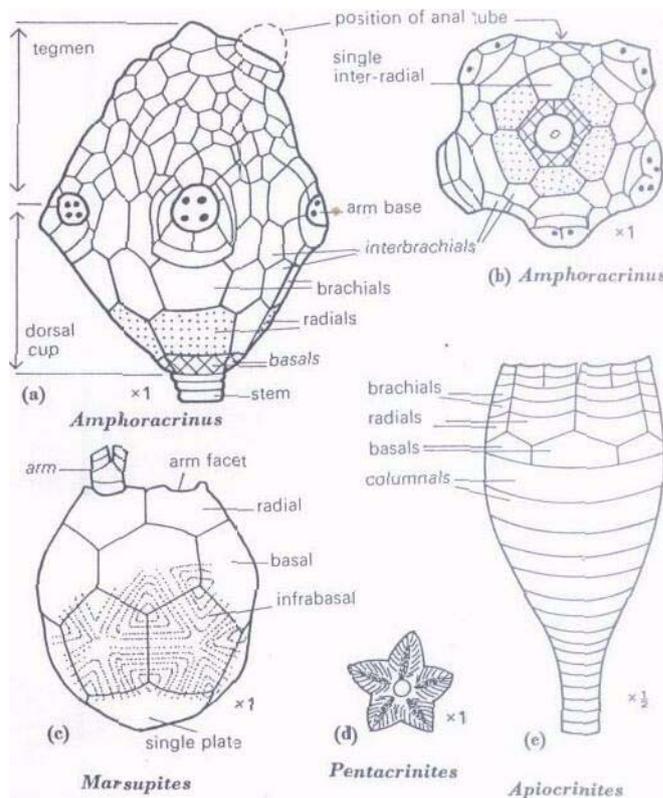
78 Morphology of the crinoids.

a, a free-swimming crinoid. b, an attached crinoid showing the disposition of the main parts of the body; the arms are incomplete* c, the articular surface of a stem plate (**columnal**). d, aboral view of the dorsal cup. e, oral view of the calyx to show the food grooves converging

on the mouth.

The **TEGMEN** (on the oral side of the calyx) may be a membrane studded with discrete plates, or a rigid structure doming over the mouth and adjacent food-grooves. The **ANAL OPENING** lies in the posterior **inter-radius** (fig. 78) between two food-grooves and is either on the surface of the **tegmen** or at the tip of a tube, the **ANAL TUBE** (fig.78b).

The arm plates (**BRACHIALS**) articulate freely. They are cylindrical in shape, with a **V-shaped** incision, on the oral side, to accommodate the food-groove. The stem plates (**COLUMNALS**) also articulate freely. They are discoid plates of circular (fig.78c) or star-shaped outline (fig.79d), and each has a central hole through which an extension of the soft parts passes.



79 Crinoids.

b, aboral view of dorsal cup. In **(c)** the surface marking is drawn in on two plates only.
d, articular surface of a columnal.