ECHINODERM LABORATORY

Phylum Echinodermata

Class Crinoidea
1. Comatulid crinoid – observe the loss of a stalk, free-living crinoids
   *Antedon bifida* – thin, pinnate arms, 25 short cirri arising from a central disk
2. Stalked crinoid – permanently attached

Class Ophiuroidea
1. *Gorgoncephalus eucnemis* – branching of arms repeatedly dichotomous, color varies
2. *Ophioderma brevispina*
3. Live ophiuroid to observe movement and behavior

Class Asteroidea
1. *Asterias rubens* – whole preserved specimens for dissection
2. *Asterias rubens* – model
3. *Asterias rubens* arm, cross-section
4. *Asterias rubens* – development, bipinnaria, brachiolaria larva
5. *Oreaster reticulates* – Caribbean cushion star
6. *Pisaster ochraceous* – Pacific sea star, arm number varies between 4-7
7. *Patira miniata* – bat star, very broad disk, arms practically indistinct, 4-9 arms, aboral surface, crescent shaped ossicles

Class Echinoidea
1. *Arbacia punctulata* – preserved specimens for dissection
2. *Lytechinus variegatus* – variegated sea urchin (Caribbean), live specimens for embryology, observe pluteus
3. *Strongylocentrotus droebachiensis* – green sea urchin, test only
4. *Encope emarginata* – bowed petals, test disoidal with flat base
5. *Melitta quinquiesperforata* – key hole urchin, tropical
6. Spatangoid sea urchin heart urchin, observe ambulacra, peristome and periproct, lantern absent

Class Holothuroidea
1. *Cucumaria* – preserved specimens for dissection
2. *Cucumaria* – preserved specimens, observe external structure, particularly tentacles
PHYLUM ECHINODERMATA

The phylum Echinodermata is clearly separated from all other phyla. Its members are coelomate, and the coelom is of great importance not only in carrying and distributing nutrients, respiratory gases, excretory and storage products but also in functioning as a water-vascular system. The water-vascular system operates the hydraulic, extensible tube-feet which are diagnostic of the phylum and which play an essential role in the life processes of these animals and their interaction with the environment.

Echinoderms comprise a large phylum of specialized marine organisms that are interesting for both their striking body form, their deuterostome characteristics and phylogenetic position as precursors to the vertebrate line. Though adults of most echinoderms show radial symmetry, this does not ally them with the Cnidaria. The radial symmetry of echinoderms is a secondary characteristic associated with their sessile or creeping lifestyle. The larval stages of echinoderms are actively swimming bilaterally symmetrical animals.

Most echinoderms have a calcite skeleton. In some, such as ophiuroids (brittle stars), the skeleton is in the form of rods supporting arms and other projections; in others, such as asteroids (starfish) and echinoids (sea urchins), it forms a more-or-less rigid capsule; finally, in others, such as holothuroids (sea cucumbers), it is highly reduced and represented only by isolated spicules in the integument. The skeleton is generally not solid, but is built as a crystalline calcite meshwork, with living protein material permeating the crystalline framework. The better-known members, such as sea urchins, brittlestars, and starfish, have skeletal spines to which the name Echinodermata (spiny skinned) refers. But possession of spines is not diagnostic of the phylum.

The earliest echinoderms were thought to be cup-shaped animals with a five-part symmetry (pentamerous), and a sessile lifestyle with the mouth uppermost and the arms held out radially to catch food. The crinoids (sea lilies) are the only extant group to retain this primitive form. From this form, two different patterns evolved: one (Asterozoa) showed radial growth patterns as evident in starfish and brittle stars, while the other (Echinozoa) showed fusion of the original radial appendage plan as seen in urchins and sea cucumbers. While the Asterozoa universally retain radial symmetry, there is a tendency within the Echinozoa to assume a tertiary bilateral symmetry. This is reflected in the worm-like body of holothuroids (sea cucumbers) and in the heart shape of some irregular echinoids (urchins). Asterozoa and Echinozoa can be considered subphyla of Echinodermata.

I. SUBPHYLUM CRINOZOA

Mouth uppermost, arms well-developed and often branching; sealilies and feather stars. Crinoids are the most primitive echinoderms. Early fossil crinoids had stems, by which they were attached permanently to the substrate, but subsequently the stem was lost so that the animal could swim or crawl. The mouth is always directed upward and feeding is accomplished by filtering with the arms. The arms are also used for swimming. You have some specimens i.e. Antedon sp. free-living comatulids in lab for observation.

II. SUBPHYLUM ASTEROZOA

= Star-shaped; mouth on undersurface.

A. CLASS OPHIUROIDEA
Arms cylindrical and sharply demarcated from the central disc; brittle stars. Based on the coelom and water vascular system, brittlestars are thought to be the group next most primitive to the crinoids. They are also highly successful and probably outnumber all other classes of echinoderms in number of species.

B. CLASS ASTEROIDEA
Arms not sharply demarcated from the central disc, well-developed water vascular system with suction tube feet; starfish. Whereas the ophiuroids use their arms for propulsion over the sea floor, asteroids rely on movements of the tube-feet for locomotion, and while ophiuroid skeletons are fragile, asteroid skeletons are strong and capable of pulling apart bivalve shells.

III. SUBPHYLUM ECHINOZOA
= Globose or worm-like, without radiating arms; some tertiary bilateral symmetry.
A. CLASS ECHINOIDEA
Skeleton consists of heavy plates that enclose the body in a rigid test. Sea urchins and sand dollars.

B. CLASS HOLOTHUROIDEA
Bilaterally symmetrical with an elongated oral-anal axis; skeleton reduced to ossicles in the integument; filter and/or deposit feeding with modified oral tube-feet called buccal tentacles.
CLASS OPHIURIDEA

Genus Ophioderma

Obtain an Ophioderma specimen and place it in a fingerbowl of seawater for examination under the dissecting microscope. Brittle stars are superficially similar to asteroids, but their long sinuous arms are more distinctly set off from the central disc and they locomote and feed in an entirely different manner. The mouth is located in the center of the oral surface of the central disc and is surrounded by five triangular jaws. The arms have reduced tube feet called tentacles that issue from between the skeletal plates or shields of the oral surface of the arms. There is no ambulacral groove and the skeletal plates are arranged so that the arms are flexible. On the edge of the central disc are located ten pairs of genital bursae that store gametes. Note the rough nature of the spines that are used for gripping the substrate, and the absence of suctorials discs on the tube feet. How do brittle stars move? Examine the aboral surface of Ophioderma. Can you locate a madreporite? pedicellariae? dermal papulae?

The skeletal plates of the ophiuroid skeleton form a complete, rigid covering over the central disc. The skeleton of the arms consists of two parts: an outer skeleton composed of aboral, oral, and lateral shields, and an internal series of vertebral ossicles. This arrangement is designed to allow the arms to move freely and enables the brittlestar to crawl rapidly and swim. To examine the skeletal structure of Ophioderma, remove the distal part of an arm and place it in sodium hypochlorite to clean. Examine and describe the skeletal plates. How are they designed to allow movement? Try to observe both crawling and swimming movements. Some brittlestars have feathery spines that allow them to swim quite effectively.

Feeding:

Ophiuroids are microphagous ciliary-mucoid feeders and may feed macrophagously as well. Mucous glands in the integument produce a network of mucus on the surface of the arms, and the mucus and food entrapped by it are moved by cilia, tube feet, and arms to the mouth. They also sweep their arms over the substrate to capture larger food particles, which may be brought to the mouth by flexion of the arms or by passage from podia to podia.

Place your Ophioderma in a fingerbowl and offer it pieces of chopped mussel in the following sizes to detect different feeding modes: 1) 10 x 5 mm; 2) <2 mm squares, and 3) finely-ground mussel. In hopes of observing a mucous net, introduce into the dish of seawater a weak solution of toluidine blue so that the water is colored a faint blue.

CLASS ASTEROIDEA

Genus Asterias

Obtain a small specimen of Asterias rubens and place it under the dissecting microscope for external observation. Carefully examine the oral and aboral surfaces and identify the structures. The mouth is located on the oral surface of the central disc, and radiating outward from the disc are five arms or rays. Running down the center of each ray is the ambulacral groove with four rows of tube feet. The roof of the ambulacral groove contains a radial nerve, which you may be able to distinguish from the other tissue. Closely examine the structure of the tube feet which originate lateral to the radial nerve. Try to watch a tube foot attach to a probe. Modified spines border each ambulacral
groove and the mouth. The ambulacral spines serve to protect the tube feet, while the oral spines help move food into the mouth. Locate the tentacle at the end of each ray. These tentacles are modified tube feet and have a sensory function. At the base of each tentacle is located an eyespot which is light sensitive.

On the aboral side of your Asterias locate the conspicuous dome-shaped madreporite (sieve plate) which opens into the water-vascular system. The function of this perforated plate is uncertain. It appears to function either as a device for ensuring equal pressure within the water-vascular system and the external environment, or as a pressure receptor for providing information to the tube feet about the changing head of water above the animal as the tide rises and falls. A small anus is located in the interradius clockwise from the madreporite. The rays on either side of the madreporite are termed bivium arms and the remaining three arms are called trivium arms. The aboral surface is covered by cilia and calcareous tubercles, spines, and beak-like pedicellariae.

To examine the skeleton and ossicles of Asterias, remove a small piece of skin and boil it in sodium hypochlorite. Examine the ossicles under the compound microscope and sketch them so you can compare them with ossicles from the other echinoderm classes. The intact skeleton of Asterias consists of articulating ossicles (plates) of calcite (calcium carbonate) held together by leathery connective tissue. Be sure you closely examine the surface skeletal structure of Asterias.

Carefully cut into the aboral surface tracing the central disk outline. Trace out the path of the water vascular system. The madreporite opens into the stone canal which leads to the ring canal around the esophagus. Tease around the digestive tract to see these
structures. On the edge of the radial canal are nine swollen areas referred to as **Tiedemann's bodies**. Their function is uncertain, but they are thought to filter the water vascular system of debris with the aid of the amoebocytes which are found concentrated there. They are then much like the lymph nodes of vertebrates. Leading from the ring canal are five radial vessels each running the length of a single ray. Along the radial vessels are located the tube feet and ampullae. How do the tube feet work? What is the function of the **ampullae**? Examine a prepared slide of a cross section of a starfish ray to get a better look at the functional organization of the water vascular system.

Now locate the structures of the digestive system. A short esophagus leads from the mouth and connects to the stomach. The stomach is divided into a globular protruding cardiac portion and an aboral pyloric region. Running from the pyloric portion into each arm are a pair of hepatic caeca that function in digestion and food storage. The rectum runs to the aboral surface from the pyloric stomach and exits via the aboral anus. Cardiac retractor muscles control the protrusion of the cardiac stomach.

The testes or ovaries of *Asterias* are paired organs located in each ray. Asteroids are dioecious. Each gonad is attached by a gonoduct to the exterior via a gonopore located at the junction of the rays.

**CLASS ECHINOIDEA**

**Genus Strongylocentrotus**

Obtain a specimen and examine the oral surface and locate the mouth which bears five protruding teeth used for scraping and chewing algae. A soft, membranous area called the peristome surrounds the mouth and has modified buccal tube feet which have a chemosensory function. At the edge of the **peristome** are five pairs of gills that are invaginations of the body wall that communicate with the coelom and are thought to have a respiratory function. On the aboral surface locate the **periproct**, madreporite and **genital plates**. The genital plates are perforated and provide exit for the gametes.
Between each genital plate is an ocular plate which has a single pore through which a modified light-sensitive tube foot/tentacle emerge.

Examine the surface of your urchin under the dissecting scope. Note that the entire external surface is ciliated. Examine the spines of Arbacia. Are they all similar? Why is this so? Examine how the spines are attached to the surface of the test (skeleton). Locate the tube feet on the urchin and note that they are restricted to five bands on the test known as the ambulacra. The ambulacra areas are separated from each other by five interambulacral regions which have no tube feet. It should be easy to envision the relationship between starfish and urchin after seeing this basic five-part pattern.

With a saw or pair of scissors, cut through the equator of the urchin and separate the two halves. Carefully examine the internal structures of your urchin. Chip off a large piece of test containing both ambulacral and interambulacral regions and boil it in sodium hypochlorite. Examine it closely under the dissecting microscope and compare echinoid test structure with the ossicles of other echinoderms.
Pay particular attention, when examining the internal structures, to the Aristotle's lantern. The lantern is composed of muscles and calcareous plates and is used in feeding and in boring into the substrate in some urchins.

CLASS HOLOTHUROIDEA
Genus Cucumaria
In stark contrast to other echinoderms, holothuroids have assumed a worm-like shape, with mouth and anus at opposite ends of a cylindrical body; but the basic pentameric structure of the typical echinoderm is still evident. The former five-part symmetry is particularly evident in the arrangement of tube feet and muscles. Holothuroids have the most reduced skeleton of all the echinoderm classes. It consists of numerous isolated plates and spicules in the body wall. Calcareous plates, however, give support to the mouth, cloaca, tentacles, madreporite, and ring canal. Examine the body wall of *Cucumaria* under a dissecting microscope and cut out a piece of wall material to examine the spicules. Boil the piece in sodium hypochlorite and describe the spicules. How do they compare with the other ossicles you have seen.

To open your *Cucumaria* make a ventral incision from the mouth to anus, open the incision, and pin the specimen to a dissecting pan. In cutting, be sure you don't harm the internal organs. Identify the dorsal madreporite and stone canal, which hang free in the coelom. The stone canal connects to the water vascular ring canal, which surrounds the esophagus. The ring canal has two elongate sacs called polian vesicles which are thought to be reservoirs of water vascular fluid. From the ring canal, radial canals run anterior to the oral tentacles, and then turn back as posterior branches that are embedded in the longitudinal muscle bands and give rise to the tube feet. Five paired bands of longitudinal muscles run the length of the body wall. At the anterior end retractor muscles, attached to a calcareous ring function to retract the tentacles into the body. Circular muscles line the body wall and are thickened as sphincters around the mouth and cloaca.

Locate the respiratory trees, which are the two large branching organs that lead out of the terminal end of the intestine. These are the structures that are ventilated by the cloacal breathing.

Identify the components of the digestive system, including the mouth, pharynx, esophagus, stomach, intestine, and cloaca. Can you determine the feeding mechanism of holothuroids by a close examination of the tentacles? Examine the contents of the stomach and intestine for parasites and commensals.