Invertebrate Zoology - BIO 353
Mollusca II
bivalves, tusk shells, squid and octopus

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Bivalvia

The clams and their relatives are generally sedentary molluscs with large, external, bivalved shells. The head is reduced, while the visceral mass, mantle, and mantle cavity, and, usually, the foot are large. Except in the protobranch bivalves, which probably represent a more primitive condition, the ctenidia are greatly expanded within the mantle cavity and serve as filter-feeding structures in most bivalves. The shell valves are lateral—that is left and right—and joined by a hinge, with specialized interlocking teeth, on the dorsal side of the animal. In clams, the mantle is often elaborated into siphons at its posterior edge.

Protobranch bivalves. Nut shells (*Nucula* and *Nuculana* spp. Figs. 12-94, p. 373). While most modern bivalves are suspension feeders, the protobranchs adopt what is probably a more primitive mode of feeding for bivalves, namely selective deposit feeding. This is accomplished with the labial palps, which appear as a pair of flaps on each side of the mouth. From each set (pair) of palps an elongate tentacle extends, and these probe the substrate to pick up particles of food which are then sorted by the labial palps themselves. The gills in protobranchs serve only a respiratory function.

Look at the preserved specimens of nut shells on demonstration. Find the foot, ventral-most in the mantle cavity, with its frilled edge. The ctenidium is situated at the posterior end of the body; its axis, and the gill-plates arranged along the axis, can clearly be seen. Anterior to the ctenidium is a prominent fold of tissue, the labial palp; in *Nucula* the palp is larger than the ctenidium. At the posterior edge of the labial paip, between the palp and the ctenidium, the proboscis may be visible. Flanking the visceral mass on the dorsal side are the posterior and anterior adductor muscles, looking like brown ovals. Identify the mantle, lining the shell, and, on the shell itself, note how the hinge has many teeth in a row, a characteristic of this primitive group of bivalves. (How do the hinge teeth compare in the other bivalve shells on demonstration?)

Anatomy of the bivalves We will take a close look at bivalve anatomy using *Mytilus* (the blue mussel) or other bivalves that may be available, including *Modiolus* (the horse mussel), *Mya* (the soft-shelled clam), oyster, quahog, and surf clam. You may choose any one of these for your own dissection; then compare what you find with what your neighbors find working on other (and the same) species.

Mytilus. Blue mussel (*Mytilus edulis*. Figs. 12-110 A, B; 12-98 A, B; pp. 388, 378). Like most bivalves *Mytilus* is a filter feeder, using the expanded surface of its gills to sort suspended particles from the water the gills pump into the mantle chamber. *Mytilus* occurs in immense beds in rocky intertidal regions on both coasts of the United States. The animals attach to rocks, shells, and each other by byssal threads which are collagenous threads secreted by glands at the base of the foot. Watch live animals in the aquarium to see how the shell gapes to allow water to flow through the mantle folds at the rounded posterior end of the shell. Two openings are evident, something akin to siphons but not called such; the one with the fimbriated margin is the inhalant opening; the other one, dorsal to it, is the exhalant. Note how byssus threads in attached animals fan out from a point on the shell where the foot can be protruded. The animal can break its attachment and move to a new site as the need arises. Young animals, smaller than about 1 cm long, are more mobile and may be seen in the aquarium or in one of the specimen dishes gliding around, or hitching themselves along, with the foot.

Modiolus. Horse mussel. Like *Mytilus*, this mussel attaches to hard substrates with byssus threads. It is easily distinguished by its thick, brown periostracum which usually even extends as beard-like threads from the shell. The beaks of the umbo are placed to one side, while those of *Mytilus* are at the apex. (For anatomy, treat as *Mytilus*.)

Spisula. Surf clam. This is the largest bivalve on the north Atlantic Coast, a heavy-shelled clam, found mostly subtidally. It is commercially important (good to eat) in some areas. (For anatomy, compare to *Mercenaria*, Figs. 12-89, 12-92; p. 368, 370)

Mercenaria. Quahog (a native-American name, pronounced "ko-hog"). The shell is thick and solid, and rounded, as if the animal inflates it. A commercially important (good-to-eat) clam.

Crassostrea. (American oyster. Fig. 12-113.) The shell is rough and heavy and generally flattened. The uper valve is smaller and flatter than the lower shell which is cemented to the substrate. Contrary to popular belief, valuable pearls are not likely to be found in this bivalve; the nacreous layer of the shell is rather dull, as would any pearls produced by the animal.

Examine one of the whole $MgCl_2$-relaxed animals at your work station. We will be removing the left shell; to identify it, remember that the anterior end of the shell of most species is that toward which the umbo points; the siphons are at the posterior end. Lay the animal on its right side and, while propping both hands against the shell, insert a scalpel blade at the postero-ventral end, slipping it between the mantle and the left (upper) shell. (Use caution! Keep your hands propped against the shell, and don't let the blade slip and cut you.) Carefully, while gently lifting the left shell, scrape the mantle from right shell, working toward the hinge until you cut through the posterior adductor muscle. Then scrape further forward to cut the pedal-retractor and anterior adductor muscles from their attachments on the shell. Gently pry the shell up and away from the mantle and rest of the animal. (Don't just rip the shell upward, or you will tear the flesh and make it unrecognizable.)

It will be easier to identify some structures with the animal submerged in liquid, as usual, so use a dish with magnesium chloride or sea water.

Identify the white muscle masses: the anterior and posterior adductor muscles, the six or so pedal retractor muscles, and the anteriorly positioned pedal protractors. Note their scars on the shell. Note also the pallial line on the shell, a line showing the site of attachment of the edge of the mantle. Find the inhalant and exhalant openings again.

While the animal is still fresh, it may be easier to find the heart as it beats inside the rectangular pericardium on the dorsal side of the animal above the attachment of the gills. Gently slit open the pericardium to expose the heart and note how the rectum goes through the ventricle! The auricles are thin sacs opening into the ventricle at its midpoint (and covered by brown pericardial glands).

Peel up the edge of the mantle and cut through it, then view the cut edge-on to see the inner and outer mantle lobes and the middle fold and periostracal groove. Raise the mantle flap and cut it off near its attachment to the rest of the body. This will expose the two gills, each of which appears as an inner and outer demibranch on either side of the visceral mass. Each demibranch can be seen to be a double sheet, a descending and an ascending lamella of filaments. In the mussel, these filaments are only loosely joined together by ciliary tufts (filibranch condition); in the oyster they have more tissue junctions keeping the filaments together (pseudolamellibranch); and in the other bivalves, they are in more continuous, more solid sheets (eulamellibranch). Gently separate a few filaments to test the strength of these junctions. The easy fraying in the mussel is typical of the filibranch gill.

The axis of each gill is fused to the dorsal wall of the mantle cavity, and by the folding of the gill into lamellae it separates the dorsal part of the mantle cavity from the ventral part as discrete chambers. Water enters the ventral chamber, passes through the gill lamellae, and leaves the mantle cavity via the upper chamber and exhalant siphon.

Find the two labial palps at the anterior edge of the gills; a pair on either side encloses the narrow ends of the two demibranchs. Between the palp pairs lies the mouth. Place a drop of carmine suspension in the mantle cavity and watch how the cilia of the gill and labial palps move the carmine particles. The cilia can be seen even better by cutting a small square of gill out and examining it mounted on a slide and coverslip under a compound microscope.

The foot is a muscular projection directed anteriad. In *Mercenaria* and *Spisula*, it is substantial and used for burrowing; in *Mya* it somewhat smaller. In *Mytilus* the foot is rather small, brown, and finger-like and serves not only for creeping but to lay down the byssal threads, molding them in a groove in its ventral surface from secretions released by the byssal glands at its base. In *Crassostrea*, the foot is reduced.

Cut away the gills on the upper side of the animal. Find the kidney (renal organ) extending from the labial palps to the posterior adductor. The kidneys are reddish brown, and lie dorsal to the bases of the gill. The renal pore, halfway along the length of the renal organ sits on a papilla with the genital opening. While most bivalves have the gonads in the connective tissue of the foot, *Mytilus* (with such a small foot) has its gonads in the mantle, appearing here as ramifying gonadal tubules, white in the male and orange in the female. The tubules can be traced in younger animals to their convergence at the genital opening.

The nervous system can be traced through the translucent body wall. The visceral ganglia and their commissure lie on the posterior adductor muscle. The visceral connectives run forward superficially in the wall of the kidney. The cerebral ganglia and their commissure lie in front of the esophagus, deep to the mouth. Pedal commissures run back from the esophagus with the visceral trunks to diverge into the foot. You might open the base of the foot to expose the pedal ganglia.

The digestive gland is the greenish compact mass in front of the pericardium. Cutting into it will expose the stomach and the proximal limb of the intestine within which is the glass-clear crystalline style (which will probably pop out once you cut into this area). Where the larger end of the crystalline style rests in the stomach is the gastric shield and the ridged ciliary sorting areas.

Other bivalves on demonstration table and live animals in aquarium

Various living bivalves are in the aquarium, including oysters (*Crassostrea*), scallops (*Placopecten*, cf. Fig. 12-115), and horse mussels (*Modiolus*). You are welcome to take any to your seats in a clean, living-animal finger bowl.

Examine the shells of *Mytilus* and other bivalves on the demonstration table. Identify the anterodorsally located umbo and the dorsal hinge. Growth lines on the shells are evident. Find the dark, horny periostracum; and, where the periostracum is worn away, the calcareous prismatic layer. A section through a shell of a bivalve is on demonstration. Use it to refresh your knowledge of the structure of the molluscan shell and its three layers (cf Fig. 12-91): the periostracum (outermost, dark organic layer), the ostracum or prismatic layer (calcareous, underlying the periostracum), and the hypostracum or nacreous layer (also calcareous, lying next to the mantle). Which of the whole shells shows a nacreous layer?

Filibranch and eulamellibranch gills (Fig. 12-98). The histology of these two types of gill is shown in microscopes on demonstration. One demonstration shows cross sections of the filibranch gills of *Mytilus*, and on it you can see the epithelial cells of the filaments and their ciliation. Note how the filaments are separate, linked only by ciliary tufts. In the eulamellibranch condition, however, as in the other microscope showing sections of gills of a freshwater mussel, the filaments are completely fused. In the whole opened quahog (*Mercenaria mercenaria*) beside this microscope, you can see how this eulamellibranch condition makes the gills appear as solid sheets, the outer and inner lamella, therefore, perforated by ostia. Between the lamellae are the water tubes. On the microscopes, try to identify frontal, laterofrontal, and lateral cilia. You may be able to see the chitinous supporting rods on the inner walls of the filament of the eulamellibranch gill.

Look at the other demonstrations of preserved bivalves and note gill structure (for example, the intermediate nature of gill fusion in the pseudolamellibranch gills of the oyster) and differences in size of the gills, foot, digestive gland, and other internal organs.

Shipworm. (*Teredo* sp. Fig. 12-117). The specimens on demonstration of the shipworm, *Teredo*, show how highly modified this eulamellibranch is, as it is adapted to boring into and feeding on wood. Most of what you see is mantle. At the anterior end the reduced right and left valves form an efficient boring mechanism. Between them is the foot. At the posterior end, two shell remnants, called pallets, protect the dorsal exhalant and the ventral inhalant siphons.

Scaphopoda

Dentalium. (Figs. 12-123, -124.) Preserved whole specimens and shells of the tusk shell *Dentalium* are on demonstration. Though rarely seen, this animal is actually quite common in deeper water of the Gulf of Maine. The mantle and shell are elongate and fused ventrally to form a tapered tube open at both ends. The larger opening is anterior, and through it the foot can be protruded. On the specimens here, note how the margin of the mantle and foot are visible through the larger opening, and note that the foot consists of two lateral lobes and a median process; it is very effective in burrowing motions. To feed, tusk shells extend tentacle-like captacula from this anterior opening; an adhesive knob at the end of each captaculum captures small organisms from the sand such as foraminiferan protozoans.

Cephalopoda

This class includes the squids, octopus, and their relatives. Many have streamlined bodies and prominent, well developed eyes on the sides of the head and are swiftly moving carnivores. In most living cephalopods the shell is poorly developed or absent. Some fossil cephalopods had gigantic external shells; octopus has none. The eight arms are derived from the foot but surround the mouth. The siphon or funnel, also derived from the foot, marks what has become the topographically ventral side of the animal (even though the foot as a whole indicates the true morphological ventral side, as we know in comparison with other molluscs).

Nautilus. (Figs. 12-65, -66.) *Nautilus* shows what may be the primitive condition of the shell; specimen shells are on demonstration. One shell is bisected so that the partitions and chambers are revealed. Look also at the preserved specimen of *Nautilus* that has been removed from its shell and note the short tentacles, the eyes (in which the pupils are simple slits), and the siphon which is used to propel the animal by a jet-propulsion-like mechanism.

Squid. *Loligo paeleii* (Fig. 12-79).

Preserved specimens of the squid *Loligo* are on demonstration. Examine the head and foot, noting the modification of the foot into five pairs of appendages that surround the mouth. Notice that one pair is different from the other four: this pair consists of retractile tentacles, and the remaining four are considered arms (cf Fig. 12-74). The terminal portion of the tentacle is widened into a club. Examine the lower left arm; if your specimen is a male this will be modified into a hectocotylous arm, bearing small suckers on the terminal portion.

Study the suckers on one of the arms. Note that each is composed of a cup that is attached to the arm by a pedicle. Around the rim of the cup there is a supporting, toothed chitinous ring. The central basin of the cup is formed by a piston, the action of which creates a partial vacuum when the cup attaches.

Spread the arms aside in order to find the mouth. Around the mouth is a peristomial membrane, and inside its opening are the chitinous beaks (cf Figs. 12-77, -78). If your specimen is a female, the horseshoe organ can be seen in the midline, just below the mouth; this is the sperm receptacle.

Study the pair of eyes on the head. Identify the cornea, iris, pupil, and lens (cf Fig. 12-82).

The remainder of the body is called the visceral hump; it is completely enveloped by the mantle. The anterior margin of the mantle, or collar, is divided into three scallops. The projection in the dorsal midline marks the position of the internal rudimentary shell, called the pen. The two ventral marginal projections mark the position of the pallial cartilages. Note the lateral fins which project from the posterior part of the mantle. By undulating these fins, the squid can swim forward. It can propel itself backwards quickly in rapid-escape jet propulsion by contracting the mantle to force water out the funnel which lies on the mid-ventral line (cf Figs. 12-64, -75).

One specimen has its mantle cavity cut open so that the gills and some other organs are visible. Compare this specimen to the Figures beside the demonstration and in the textbook and find the gills and their branchial hearts, kidney, and parts of the digestive tract (rectum, caecum) and reproductive organs (gonad, penis or oviduct).

Octopus (*Octopus vulgaris*).

Examine the demonstration specimens of *Octopus*. Note that there are eight arms and no tentacles. Observe the suckers on the arms. Note the head, with the eyes. On either side of the head the incurrent siphons of the mantle cavity can be seen. The single, excurrent siphon is hidden under the visceral mass and mantle, which are folded back behind the head in this relaxed specimen. This position of the visceral mass is more or less characteristic in a living specimen that is relaxed.