# The Eastern Oyster: A Not-So-Typical Mollusc

Lab Investigation: Class Bivalvia *High School Version*

Lesson by Kevin Goff

## SETTING THE STAGE

The earliest animals on Earth had either irregular, **asymmetrical** bodies or **radial symmetry**, with a body shaped like a merry-go-round. Animals with these body plans usually sit still on the seafloor – like sponges, coral, and sea anemone. Others – like jellyfish – just drift along on ocean currents. These animals do not actively forage for food. Instead, they wait for food to come to them. Their body shape lets them collect food from any direction. Eventually, though, a line of worm-like animals evolved **bilateral symmetry**, with a body bearing two sides – left versus right – that are mirror images of each other. This body plan is an adaptation for **directional movement**. To understand why, just imagine a car with monster truck tires on one side and little red wagon wheels on the other. It would go in circles! Having identical left and right halves enables an animal to track in a straight line.

> **VIDEOS TO WATCH**
>
> **For dazzling displays of how asymmetrical and radial animals can harvest food from any direction, visit the Shape of Life website and watch these two clips (under "Behavior"):**
> - **Sponges: Filter Feeding Made Visible (2.5 min)**
> - **Cnidarians: Anemone Catches Goby (2.5 min)**

Animals with bilateral symmetry also usually have a distinct **head** at one end, where the **mouth** and **sense organs** are concentrated. We say they are **cephalized**, meaning "head-having." In contrast, animals with radial symmetry are not cephalized: They have no head, just a mouth in the middle. Being both bilateral and cephalized permits an animal to move in one deliberate direction – headfirst – letting their sense organs lead the way, like floodlights through a fog. Such animals can actively seek out the things they need. They can forage for food, track live prey, seek better habitat, or search for a mate.

> **VIDEOS TO WATCH**
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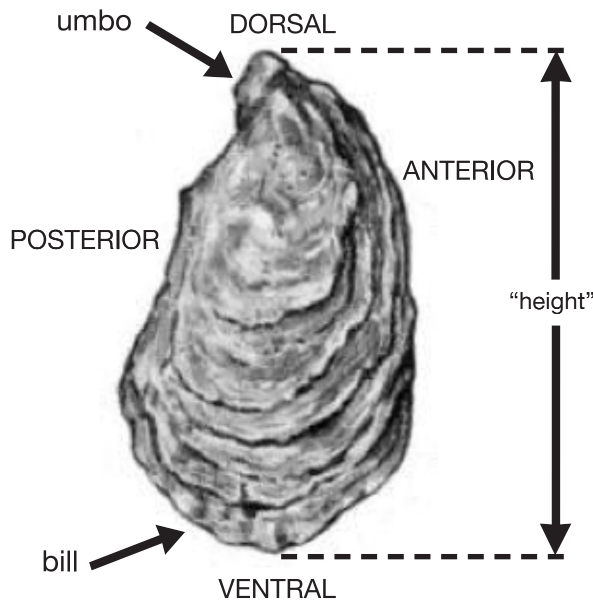
> **To see how a bilateral, cephalized body lets an animal actively seek food, watch these two Shape of Life clips:**
> - **Flatworm Animation: Body Plan (under "Animation"; 2.5 min)**
> - **Flatworm: An Invasive Flatworm Hunts Earthworms (under "Behavior"; 2.5 min)**

In time, that first line of bilateral, cephalized, worm-like animals branched into most of the animal groups we see today, from penguins to porcupines, scorpions to squid, ants to alligators, and bullfrogs to bull sharks. Among the earliest bilateral animals to appear in the fossil record are the **molluscs**: soft-bodied animals that grow a calcified shell on their backs. The first molluscs were simple snails with a shell shaped like a dome or umbrella – probably to protect them from the sun's intense ultraviolet radiation, or perhaps predators. But in time these simple animals would diversify

> **VIDEOS TO WATCH**
>
> **Become familiar with the basic mollusc body plan – and its capacity for directional movement – by watching these two Shape of Life clips:**
> - **Mollusc Animation: Abalone (under "Animation"; 1.5 min)**
> - **Molluscs: Pycnopodia Chases Abalone (under "Behavior"; 2.5 min)**

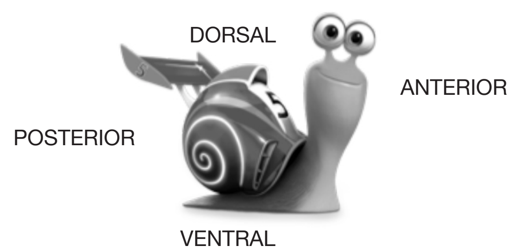
into a spectacular variety of forms, each adapted for a different lifestyle. In today's lab we'll dissect a member of a molluscan line that took some very radical turns away from the ancestral snail: **Class Bivalvia** – the **bivalves**, like clams, oysters, mussels, and scallops. Our specimen, the Eastern oyster *(Crassostrea virginica)*, is an oddball, quite different from its cephalized, bilateral ancestors. But as you study it, keep in mind that it descended from a crawling, grazing snail with an umbrella on its back!




## LAB ACTIVITY

### Foundation, Floor, and Roof

Line a dissecting tray with paper towels and get a fresh oyster and dissecting utensils. ALERT! You MUST situate your specimen correctly in your tray, as shown in the diagram. If you fail to do this, you'll get inside and find everything backwards from your diagrams!




(Images: Rainer Zenz and Icon Archive)

Here's a clue to help you glimpse the ghost of that bilateral snail from the oyster's past: When a scientist measures an oyster from the narrow **umbo** to the broader **bill**, she calls this its "height," not its "length." This is how TALL the animal is, not how LONG it is!

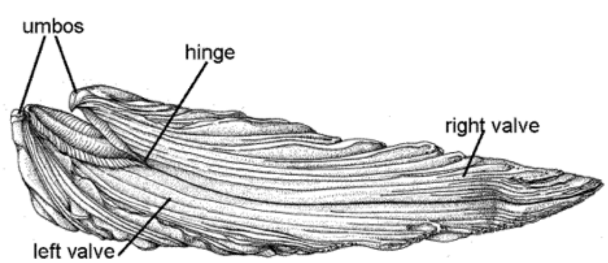



Image: Richard Fox's Invertebrate Anatomy Online (originally in Galtsoff 1964)

Here's another clue: An oyster's shell is split into two **valves**, and it naturally rests with the bowl-shaped valve beneath and the flatter valve facing skyward. One is the floor, the other the roof. And yet, when a scientist holds an oyster in the palm of her hand, she doesn't call these its "lower" and "upper" valves, but its LEFT and RIGHT valves! That's because she knows that inside the shell are the remnants of a **bilateral** snail, with a left and right flank and four main body surfaces: **dorsal** (its back), **ventral** (belly), **anterior** (head), and **posterior** (tush).

***On the diagram, mark where you think the oyster's mouth and anus will be once we get inside.***

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## Doors and Windows

An oyster sure doesn't look like a snail on the outside. To appreciate the family resemblance, you'll have to look under the hood. Its two shells – or **valves** – are joined by a tough-yet-flexible **hinge ligament** at the dorsal end. Your teacher broke the hinge ligament when opening your oyster, but you can find its remains near the umbo. Your teacher also sliced through the **adductor muscle**, which clamps the oyster shut. Lift the lid and find the tough adductor amidst the soft body tissue (see diagram below). On the upper valve you can also see the purplish scar where the adductor attached. When this muscle relaxes, the oyster springs open – just a crack – to let water circulate through. ***What two things does this water contain, necessary for survival?***

**Dinner Date Tip #1:** Class Bivalvia includes many of the so-called "shellfish" found on a seafood restaurant menu. Next time there with your sweetheart, impress him or her with the following trivia. Clams are burrowers with a thick meaty foot for digging, the perfect body part for chowders and fried nuggets. Scallops, on the other hand, don't dig, but they do swim. They do this by clapping their shells like Pac Man to squirt out jets of water. For this reason they have huge adductor muscles, and this is the disc of meat you see on your plate. But oysters and mussels have hardly any muscle at all, because they spend their entire lives cemented to a solid surface. Consequently, the brave among us just dab on a little cocktail sauce and eat the entire animal off the half shell: gut, gills, glands, gonads, and all!

Notice that the adductor is divided into a darker "quick muscle" and a white "catch muscle." When the animal is threatened, the quick muscle immediately clamps the two shells together. But it soon fatigues, so the catch muscle takes over. Though slower-acting, the catch muscle has great endurance. The Eastern oyster is an **intertidal** species, often anchoring itself to a hard surface (usually another oyster!) where the tide constantly rises and falls. ***Think! What events in the intertidal zone might provoke an oyster to slam shut and seal up for a while? Try to think of at least three:***

Shape of Life

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## Sheetrock and Interior Trim

**Oyster on the half shell**
(Image: MD Sea Grant)

Remove the upper valve. The entire body is enshrouded in a thin, flimsy blanket of tissue – the **mantle**. The mantle might now be tattered on top, damaged when the oyster was opened. But probe UNDER the body, and you'll see it's still intact, snug against the shell.

Though soft and flimsy, the mantle has a very important protective function: It creates the **shell**. First, tiny glands lay down a web of protein fibers. Next, these glands secrete a paste of calcium carbonate ($CaCO_3$) onto the web, and it hardens like plaster. ***Why do you suppose the oyster makes its shell so smooth on the inside?***

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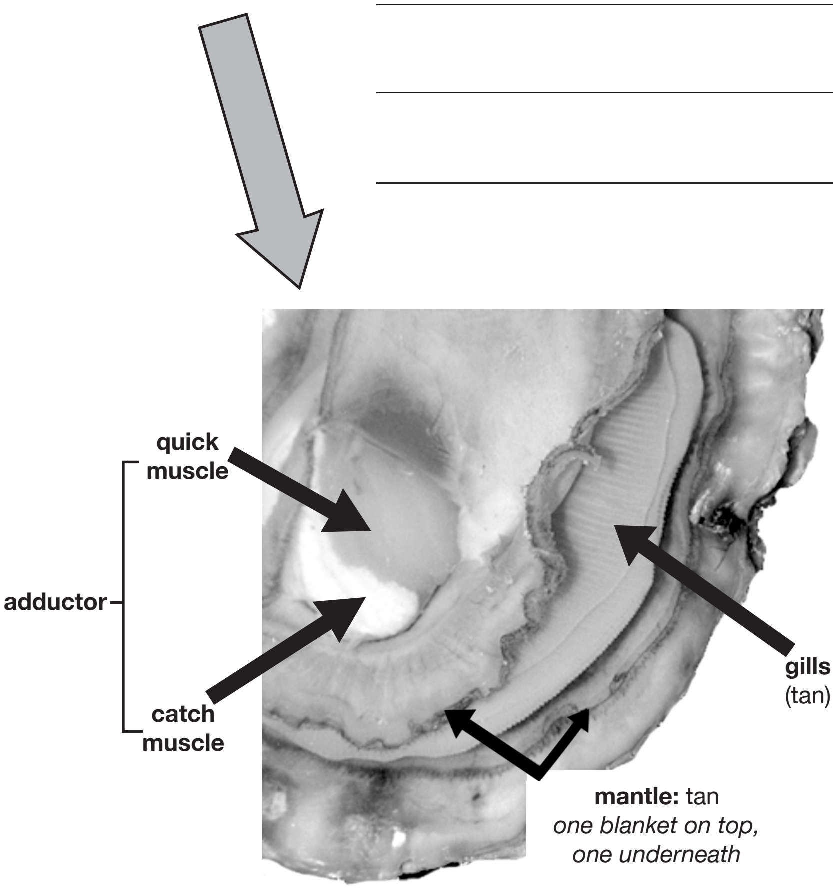
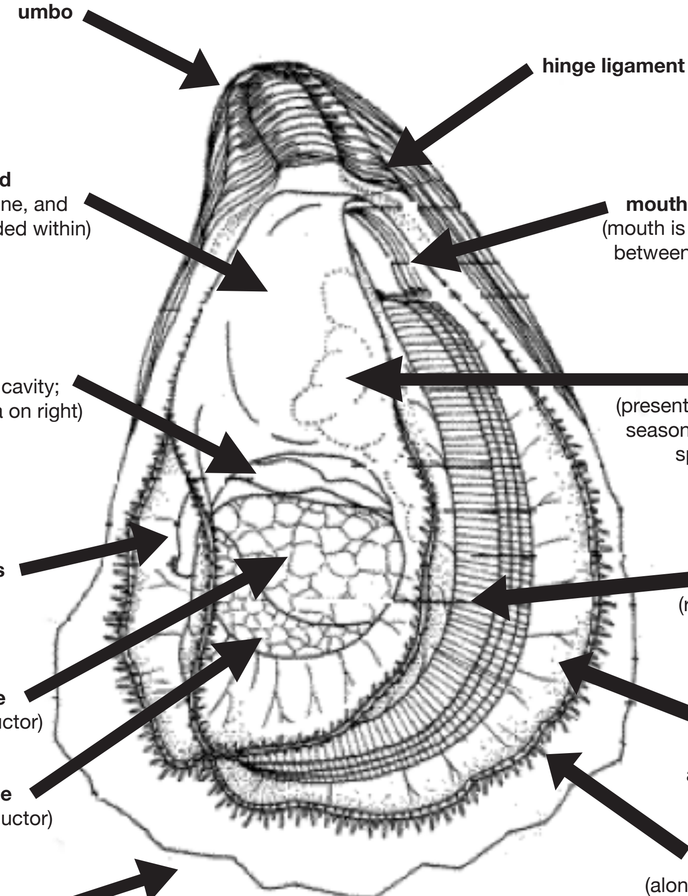



**Dinner Date Tip #2:** Next time you're at a seafood restaurant with your sweetheart, and you see oysters on the menu, astonish your date with this little known fact: Oysters do NOT make pearls! At least not the lustrous, spherical ones that are prized for jewelry. Those are built by so-called "pearl oysters," which are really more closely related to MUSSELS! And here's another myth debunked: It normally isn't sand that stimulates pearl-production, but a bit of indigestible food or a small parasite. The mantle coats the irritant with glossy **nacre**, or "mother-of-pearl." In truth, many bivalves make pearls, just irregular and unpretty ones. Hey, order a plate of raw oysters or steamed mussels as an appetizer, and maybe you'll find a lopsided pearl to present your date!

## Plumbing and Air Conditioning

For a better view of internal features, trim away the blanket of mantle lying atop the body. Lift it with fingers or forceps and remove it with scissors or scalpel.




Sketch by Richard S. Fox

Find the four flap-like **gills** (Technically there are TWO PAIRS of gills …a trace of the oyster's bilateral ancestry) in the **mantle cavity**. The mussel circulates seawater over these gills, which absorb oxygen into the bloodstream. Study them under a magnifying glass or binocular scope. ***Describe their texture. How do you think this helps increase the amount of oxygen absorbed?***

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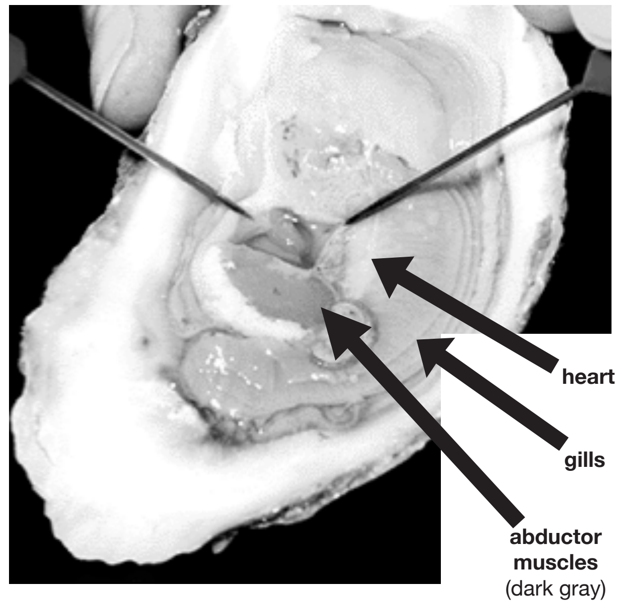
The **heart** is suspended in a room of its own, called the **pericardial cavity**, just north of the adductor (see diagram). This compartment may still be covered with a ceiling of tissue; if so, open it with scissors. The heart has three chambers: two **atria** receive oxygenated blood from the gills, and a stronger **ventricle** pumps it to the rest of the body.




(Image: MD Sea Grant)

We vertebrates have a **closed circulatory system**, meaning blood is pumped through our bodies in highly pressurized pipes. Bivalves, by contrast, have an **open circulatory system**. Although they do have a few blood vessels – indeed, the tube-like heart is just an enlarged, muscular vessel – blood mainly just soaks into spongy spaces in their tissues (called **sinuses**). Because the blood isn't pressurized, tissues don't get the direct oxygen delivery that our own capillaries provide. Also, the blood is watery and colorless; it lacks the iron-based hemoglobin that makes our own blood red and so effective at transporting oxygen. ***We vertebrates could never survive with such an inefficient oxygen-delivery system. Why are oysters able to get away with it?***

**If your oyster is fresh – hence still alive – you might occasionally see its heart slowly swell and relax. A gentle squeeze with forceps might cause it to contract in response.**

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**Dinner Date Tip #3:** As you enjoy the giant plate of spaghetti that you and your date are sharing, use this as an opportunity to impress him/her with another fascinating bit of molluscan trivia: Bivalves possess the only rotating organ in the animal kingdom – called a **crystalline style**. It's a jelly-like rod sitting inside the animal's stomach, with one end pressed against a hard plate called the gastric shield. Model the style's action for your date by twirling your fork against a spoon to reel in a long strand of spaghetti. This how the style works too: Food entering the mouth is drenched in sticky, stringy mucus, and by spinning around, the crystalline style reels it in. The food eventually spirals down to the gastric shield, where it is ground up and attacked by digestive enzymes.

Although bivalves and gastropods (snails and slugs) have open circulatory systems, there is one line of molluscs that evolved a closed circulatory system: the cephalopods (squid and octopi). They also have THREE hearts! Besides the main heart, each gill has its own heart. Also, their gills are very branched and bushy. ***What do these circulatory and respiratory adaptations probably tell you about cephalopods' lifestyle? Explain your reasoning.***

**If your oyster is fresh, try this: Snip a small section from the edge of a gill. Spread it flat in the well of a depression slide and add some water. Examine it under a compound microscope on low or medium power (not high). Look for "shimmering" along the edge and inside the channels. Those are fluttering cilia. Next, add a droplet of microscopic yeast cells to the rim of the well, near the gill but not on it. The yeast cells will look like tiny ping pong balls being swept into and through the gill's channels.**

In most underwater animals, gills are for respiration: taking oxygen from the water. But in bivalves, the gills have evolved another very important function: they harvest food! Bivalves are **filter feeders** who sift microscopic **plankton** from the water (algae and bacteria). They coat their gills with sticky **mucus**, which ensnares plankton. The gills are also carpeted with thousands of **cilia**, microscopic "hairs" that whisk back and forth like fluttering eyelashes. These sweep food up to the palps, which you can find at the anterior end of the gills. Between them is a **pinhole mouth** (hard to see). ***What do you think is the function of these leafy "lips"? (helpful hint: they're not for kissing)***

Next, food moves into the **stomach**, buried within the greenish-brown **digestive gland**. You can fillet into this region with your scalpel, but the stomach is hard to distinguish. Anything indigestible passes through the **intestine** and out the **anus**. Look for these structures on the posterior (left) side of the adductor muscle. ***Bivalves feed ONLY on microscopic, single-celled organisms. How are their gills and other body parts built for size-selective feeding?***

Another oddity of oysters is that they're HEADLESS! Remember, their snail-like ancestors DID have heads. That is, they were **cephalized**. Bivalves first appear in the fossil record over 500 million years ago, during the "Cambrian Explosion" when all major animal groups were evolutionarily diverging from one another. Among the diverse new species was a horde of predators able to crack open mollusc shells. In response, some molluscs began burrowing to safety. Still snail-like, their umbrella-shaped shell creased along its dorsal edge, probably so they could wriggle into the seafloor by flapping their shells. Their bodies gradually became wedge-shaped for easier digging. Eventually they took up permanent residence underground. They quit crawling around, stopped foraging for food, and began filter-feeding. And in time, they "de-cephalized" (lost their heads), and some species – like oysters and scallops – even "un-bilateralized" (lost their perfect bilateral symmetry). ***What selective pressures allowed the bivalve line to evolve into a headless, less symmetrical form? : Hint: Recall that bilateral symmetry and cephalization were originally adaptations for… what?)***

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## Electrical Wiring

Finally, examine the mantle's outer margin with a magnifying glass or binocular scope. It's fringed with **sensory tentacles**. These house **chemoreceptors** that detect chemicals in the environment (akin to smell and taste) and ***mechanoreceptors*** that detect vibrations and physical touch. When an intruder touches a tentacle, or when chemoreceptors get a "whiff" of a predatory starfish, the oyster slams shut. Touch a tentacle with your fingertip, and maybe you'll see a reaction. Some bivalves also have light-sensitive **photoreceptors** all along the mantle's margin, and some scallops have hundreds of bright blue eyes aiming in all directions, able to react to shadows and movements. Somewhere in the tattered remains of your oyster there are also nerve cords and ganglia (nerve centers), but nothing complex enough to call a "brain." So next time you and your dinner date share a plate of raw oysters on the half shell, take comfort that although it's still quite alive, it has no feelings or awareness and presumably feels no pain!

## Expanding the Neighborhood

Also in the tattered remains of your oyster are **gonads**, the reproductive organs that produce **gametes**, or sex cells: **sperm** and **eggs**. These aren't well developed except during summer breeding season, and even then they're more a loose mass of gametes than a discrete organ. Eastern oysters are sequential **hermaphrodites**: Most begin life as sperm-producing males, but some become egg-producing females at age two or three. Bivalves are **broadcast spawners**, releasing sperm and egg into open water. If an egg is lucky enough to bump into a sperm cell, it develops into a drifting larval form, too small to see with the naked eye. It soon grows a paper thin shell and a weak ability to swim. Later it develops a tiny foot and starts to half-swim, half-crawl along the seafloor in search of something solid to cement itself to – usually an older oyster. If it finds a suitable spot, it metamorphoses into a "spat," a filter-feeding juvenile no bigger than a fingernail. This diagram shows the oyster life cycle.