

# The Mussel: A Not-So-Typical Mollusc

High School Student Edition

Lab Investigation: Class Bivalvia

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

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)

### 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)

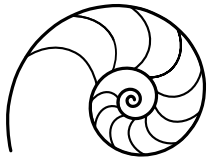
Animals with bilateral symmetry also usually have a distinct **head** at one end, where the **mouth** and **sense organs** are concentrated. We say they are **cephalized**, meaning “head-having.” In contrast, animals with radial symmetry are not cephalized: They have no head, just a mouth in the middle. 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.

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

### 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)



Shape of Life

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perhaps predators. But in time these simple animals would diversify 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 blue mussel (*Mytilus edulis*), 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

### Floor and Roof

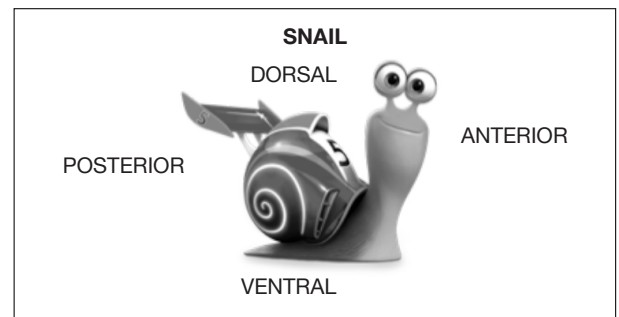
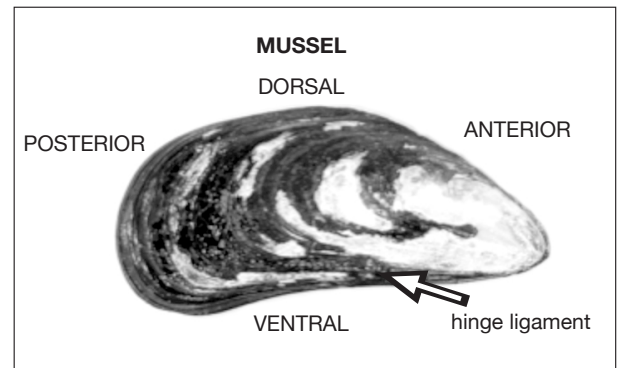
Line a dissecting tray with paper towels and get a mussel and dissecting utensils. If your mussel is pickled in preserving fluid, rinse it under a faucet to diminish the odor.

**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!

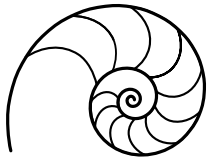
The leathery **hinge ligament**, which joins the two shells, should be on the upper right.

A mussel's shell is split into two **valves**. The way it's lying in your tray makes it seem like one valve is the floor, the other the roof. But this is misleading, for inside the shell is the ghost of a **bilateral** snail from the mussel's past. Hold it up and look at it end on, with the hinge ligament facing skyward. *If you stand your mussel on end, can you see a left side and a right side – the imperfect remains of bilateral symmetry?*

To orient yourself, compare the mussel and snail diagrams. Note that the mussel has a **left** and **right** flank – same as the snail – and four main body surfaces: **dorsal** (its back), **ventral** (belly), **anterior** (head), and **posterior** (tush). *On the diagram, mark where you think the mussel's mouth and anus will be once we get inside.*



(Images: Rainer Zenz and Icon Archive)



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## Doors and Windows

A mussel 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** on the dorsal surface, which works like a door hinge. Slip a scalpel between the valves (not too deep!) and twist just enough to open a small crack. Observe the soft, ruffled fringes of the **mantle** around the perimeter. At the posterior end the mantle has two open windows called **siphons**. The more dorsal gap is the **excurrent siphon**; the more ventral gap is the **incurrent siphon**. Together, they let water circulate in and out. *What two things does this water contain, necessary for survival?*

Now BEFORE opening your mussel all the way, READ ALL FIVE STEPS BELOW. You'll need to cut through the tough **adductor muscles**, but you want to avoid damaging the other soft tissues:

- (1) Study the diagram below to learn the location of the anterior and posterior adductors.
- (2) Slip your scalpel between the soft mantle and upper valve.
- (3) Gently peel the soft tissue away from the shell.
- (4) With luck, the adductors will now detach from the shell. If not, saw through them, as close to the shell as possible.
- (5) As you slowly pry open the mussel, peel the soft mantle away from the shell.

When a mussel is threatened, the adductors clamp the two shells together. The blue mussel is an **intertidal** species, often anchoring itself to a hard rock on the shoreline where the tide constantly rises and falls. *Think! What events in the intertidal zone might provoke a mussel to slam shut and seal up for a while? Try to think of at least three:*

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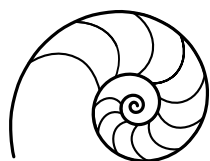
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## Sheetrock and Interior Trim

Detach the upper valve completely. The entire body is enshrouded in a thin, flimsy blanket of tissue – the **mantle**. The mantle might be tattered on top, damaged when you opened your mussel. 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 ( $\text{CaCO}_3$ )

onto the web, which hardens like plaster. *Why do you suppose the mussel makes its shell so smooth on the inside?*

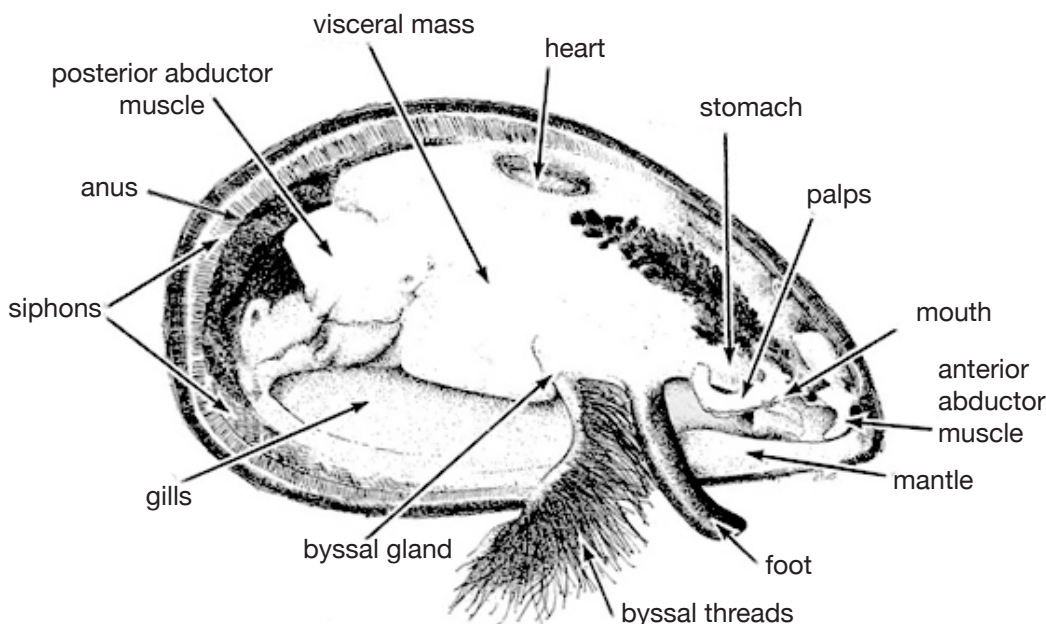


Image: Laboratory and Field Investigations in Marine Biology by Sumich & Dudley, 4th ed.

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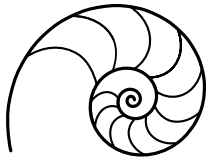


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**Dinner Date Tip #1:** Next time you're at a seafood restaurant with your sweetheart, and you see oysters on the menu, astonish your date with this little known fact: Oysters do NOT make pearls! At least not the lustrous, spherical ones that are prized 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!



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## Foundation

Find the **foot** in the anterior ventral region. Remember that the ancestral snail's foot was big and muscular for locomotion. But in the mussel, it's reduced to a little stump, useless for crawling. Yet it still serves an important function: It creates the beard-like **byssal threads** that anchor the animal to its rock. To do this, the mussel presses its little foot against the rock. The **byssal gland** then secretes a liquid protein that oozes down a groove in the foot (find this!). Finally, this stream of protein hardens into a tough byssal thread.

Thus the foot has now taken on the OPPOSITE of its original function: It was once used for moving around, but now keeps the animal motionless!

*So how do you think the feeding method of the modern mussel has changed, versus the ancestral snail?*

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## Plumbing and Air Conditioning

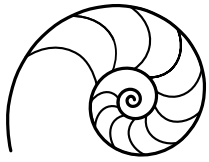
For a better view of internal features, trim away the blanket of mantle lying atop the body. Lift it with fingers or forceps and remove it with scissors or scalpel.

Find the four flap-like **gills** (technically there are TWO PAIRS of gills ...a trace of the mussel's bilateral ancestry.) 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**, near the dorsal edge (see diagram above). This compartment is probably enveloped by a wrinkly membrane. Open it with scissors or scalpel. The heart is a small nugget of muscle. It has three chambers: two **atria** receive oxygenated blood from the gills, and a stronger **ventricle** pumps it to the rest of the body.

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 especially effective at transporting oxygen. *We vertebrates could never survive with such an inefficient oxygen-delivery system. Why are mussels able to get away with it?*

**If your teacher has opened a live mussel to show you, you might see its heart slowly swell and relax! A gentle squeeze with forceps might cause it to contract in response.**

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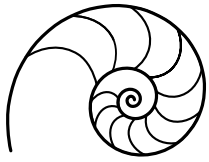
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Although bivalves and gastropods (snails and slugs) have open circulatory systems, there is one line of molluscs that evolved a closed circulatory system: the cephalopods (squid and octopi). They also have THREE hearts! Besides the main heart, each 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.*

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**Dinner Date Tip #2:** Class Bivalvia includes many of the so-called “shellfish” found on a seafood restaurant menu. Next time there, impress your sweetheart 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!

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** that 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)

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Next, food moves into the **stomach**, buried within the **digestive gland** above the foot. 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?*

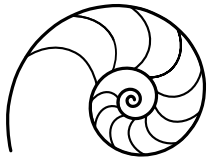
If your teacher opened a live mussel, your teacher might put a piece of gill in a well slide, to view under a compound microscope on low or medium power (not high). Look for “shimmering” on the edge and in the channels. Those are fluttering cilia. Your teacher may also add microscopic yeast cells near the gill. If so, these will look like tiny ping pong balls being swept in and through the gill’s channels.

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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.

Another oddity of mussels 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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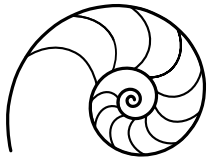
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## Electrical Wiring

Finally, examine the mantle's outer margin with a magnifying glass or binocular scope. It's fringed with **sensory receptors**. These include **chemoreceptors** that detect chemicals in the environment (akin to smell and taste) and **mechanoreceptors** that detect vibrations and physical touch. When touched by an intruder, or when it gets a "whiff" of a predatory starfish, the mussel slams shut. Some bivalves also have light-sensitive **photoreceptors** all along the mantle's margin, and some scallops have hundreds of bright blue eyes aiming





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in all directions, able to react to shadows and movements. Somewhere in the tattered remains of your mussel 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 mussels 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 mussel are **gonads**, the reproductive organs that produce **gametes**, or sex cells: **sperm** and **eggs**. These aren’t well developed except during breeding season, and even then they’re more a loose mass of gametes than a discrete organ. When mussels release their eggs and sperm into the water column it’s called spawning. 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. If it finds a suitable spot, it metamorphoses into a filter-feeding juvenile no bigger than a fingernail. The mussel life cycle is shown in this diagram.

