Shape of Life

Molluscs: Gastropod

High School Student Edition

Lab Investigation: Class Gastropoda

Lesson by Kevin Goff

SNIPS AND SNAILS AND GASTROPOD TAILS

Molluscs are a clan of closely related animals that includes snails and slugs, clams and oysters, and even squid and octopi. The name comes from the Latin *mollus*, meaning "soft," for these animals all have a soft and boneless body – though some are armored with a stony shell. Phylum Mollusca encompasses more than 150,000 species that have carved out niches in nearly all of Earth's habitats, from freshwater lakes to dry land, from the ocean's sunlit surface waters to its darkest depths, from hot tropical forests to frigid polar seas. Some are sedentary filter-feeders that spend their whole lives anchored to the same spot (oysters and mussels). Others are among the world's speediest predators (squid). Some snails drift in the sea as tiny plankton, barely visible to the naked eye, while the giant squid grows longer than a school bus. Most are utterly brainless, but octopi are the most intelligent invertebrates on the planet. Some live only a year, others are older than you or I will ever be.

Despite their spectacular variety, most molluscs belong to one of only three classes: **Gastropoda**, **Bivalvia**, and **Cephalopoda**. Today we'll focus on gastropods – the snails and slugs.

Snail Trails

Gastropod means "stomach-foot" – an apt name for an animal that crawls belly-down on a single, muscular foot. Get a pond snail, garden slug, or other gastropod from your teacher. Place it in a petri dish or other transparent container. If it's an aquatic species, add water from its natural habitat. Be patient and with luck it'll become active. Study it with a magnifying glass or binocular microscope. Observe its underside through the clear wall of the container, holding it overhead if needed. Look for wave-like motions in the foot and a trail of slippery mucus. ***Describe any patterns of movement that you see:***

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Sketch a side view of your gastropod and label it with these 4 terms: **anterior** (its head), **posterior** (its trailing end), **ventral** (its belly or underside), and **dorsal** (its back).

Sketch with labels

Look for sensory tentacles at the anterior end. These carry mechanoreceptors for touch, chemoreceptors for smell/taste, and simple eyes at the tips, with photoreceptors to detect light, shadows, and movement. Examine a tentacle and eye under magnification. An interesting thing to do is to (gently!) touch its eye. ***Describe the reaction:***

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Walk like a Water Balloon

When you touched your slug or snail's eye, it probably retracted its tentacle. After a few seconds it probably telescoped back out. The motion is similar to turning a sock inside out, but driven by **hydrostatic pressure**, like squeezing one end of a tube of toothpaste or blowing into a curly New Year's Eve horn. This way of moving is a specialty of molluscs, made possible by their boneless, blood-filled bodies. We have a **closed circulatory system**, meaning blood is pumped through pressurized pipes (arteries). Gastropods, by contrast, have an **open circulatory system**. Although they do have a few blood vessels, blood mainly reaches their cells by soaking into open spaces (called "sinuses") within their tissues.

A snail is therefore built like a spongy water balloon, and this serves as a **hydrostatic skeleton**. Our muscles work by tugging on a hard skeleton, but molluscs don't have bones. Instead, a snail's muscle fibers coil and crisscross around its blood-engorged tissues. By contracting these in various combinations it can protrude parts of its body, curl up, turn corners, twist, and so on.

You can mimic this way of moving with a water balloon. Fill a long balloon about 2/3rds with water and tie it off. Imagine this is a slug's body. Let your hands be its muscles. Set it on the table and squeeze it at different angles. ***Can you make it turn, twist, or stretch out?***

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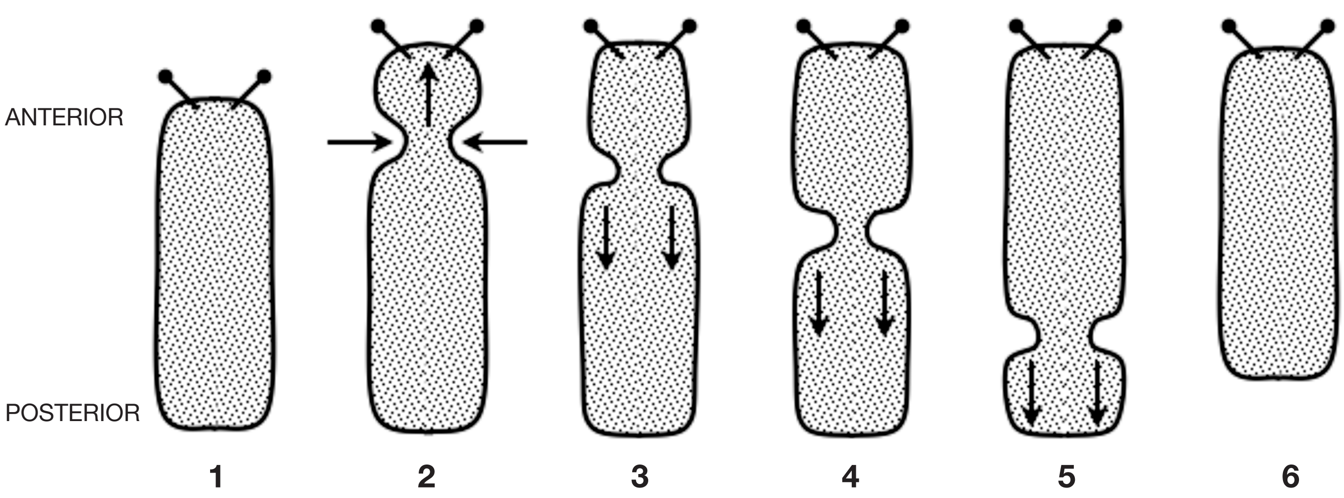
Many gastropods crawl using a **retrograde wave**. The animal squeezes its muscles in a BACKWARDS sequence, and this results in FORWARD movement! The first contraction causes the head to stretch forward. Then a second contraction squeezes more fluid forward, filling in the space behind the head. Next, a third contraction squeezes more fluid forward. And so on. As the muscle contractions migrate backwards, the blood and body are squeezed forward! The animal also lays down a trail of slimy **mucus** to grease its way.



You can model this with your water balloon. Wrap a hand around it near the front end. Squeeze to make its "head" stretch forward (see step #2 above). Now wrap your other hand just behind the first. Relax your first hand as you squeeze your second hand, pushing more water forward (step #3). Now slowly work your way hand-over-hand toward the REAR, squeezing water FORWARD as you go: a retrograde series of contractions. ***Can you get your homemade slug to creep along, a few inches at a time?***

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A Very Special Bathrobe

In addition to the foot and hydrostatic skeleton, molluscs have other special traits that distinguish them from other animals. One is the mantle, a blanket of soft tissue that covers a mollusc's body like a bathrobe. (In days of old, a "mantle" was a sleeveless cloak that people draped over their garments.) The mantle has a very important function: It creates the shell. It does this in two stages: First, tiny glands lay down a web of protein fibers. Next, the glands secrete a paste of calcium carbonate ($CaCO_3$) onto the web, which hardens like plaster. In many species, the mantle lays down a shell in a highly defined pattern resulting in coiled shells that are often brilliantly colored and beautifully patterned.

VIDEO TO WATCH

To see the mantle's handiwork, visit the Shape of Life website and watch "Mollusc Animation: Shell Repair" (1.5 min; under Animations). The scientist is Gary Vermeij. Blind since birth, he studies fossil seashells not with his eyes but with his hands!

Vermeij's research shows that the oldest fossilized shells were simple domes, shaped like an umbrella. But later, a tremendous variety of more complicated shapes appears in the fossil record: coils, cones, and tall twisting towers, often decorated with spikes and spines and elevated ridges. ***Why do you think gastropod shells gradually "diverged" from a simple dome into so many complex shapes?***

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Chainsaws and Crossbows

A nother unique Molluscan trait is the **radula**, a long ribbon-like tongue coated with overlapping teeth. This toothy tongue operates much like a chainsaw for rasping food into the mouth. Most molluscs use it to scrape up plant matter or meat, but some predatory snails use it to drill holes through other molluscs' shells! And in the handsome but deadly cone snails, the radula has been modified into a hunting dart armed with a powerful venom. The sting of some cone snails can be lethal to any human foolish enough to try adding one to his seashell collection!

VIDEO TO WATCH

For vivid footage of all these traits – foot, mantle, shell, radula, hydrostatic skeleton, and retrograde waves – visit the *Shape of Life* website and watch the first 8 minutes of "Molluscs: The Survival Game" (under Phyla; stop at the nautilus).

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Early in their evolutionary history, gastropods used their foot only for crawling. And they used their radula to graze on algae or scrape up food. But in modern moon snails – as seen on the *Shape of Life* – the foot and radula “diverged” for NEW functions and a NEW lifestyle. ***Explain:***

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You Go Your Way, I’ll Go Mine

The narrator in the *Shape of Life* video says, “When they first appeared over half a billion years ago, molluscs were but tiny creatures inching around under a protective shell. How did the struggle for survival create so many variations on their original body plan?” What he is describing is **divergent evolution**: the branching of a SINGLE ancestral line into NEW and DIFFERENT body forms. Molluscs evolved new body features and new behaviors for new functions and new lifestyles.

It may be hard to believe that a snail, squid, and clam are close kin, but if you examine their major body features, you’ll see they have much in common! ***Let’s do a little “painting by numbers” with colored pencils to help you understand how all modern molluscs “diverged” from the same original body plan:***

- ❑ **Mantle and shell** – Again, the mantle is a soft blanket of tissue that produces the shell. Outline these in a dark color, using the same color for all four animals.
- ❑ **Mantle cavity** – This is an open space under the shell and mantle where water circulates across the **gills**. Dashed arrows show the flow of water. Shade in this cavity with a light blue color on all four animals.
- ❑ **One-way gut** – Jellyfish, sea anemone, and flatworms all have a dead-end stomach, with only one opening. But molluscs were among the first animals to evolve a one-way gut, with a **mouth** at one end and **anus** at the other. Shade this on all four in the same color.
- ❑ **Head/foot region** – This contains the mouth, sense organs, and muscular motor organs for movement. Shade with a light color.
- ❑ **Visceral mass** – This is a spongy region that houses the internal organs of digestion, circulation, excretion, and reproduction. Shade with a light color.

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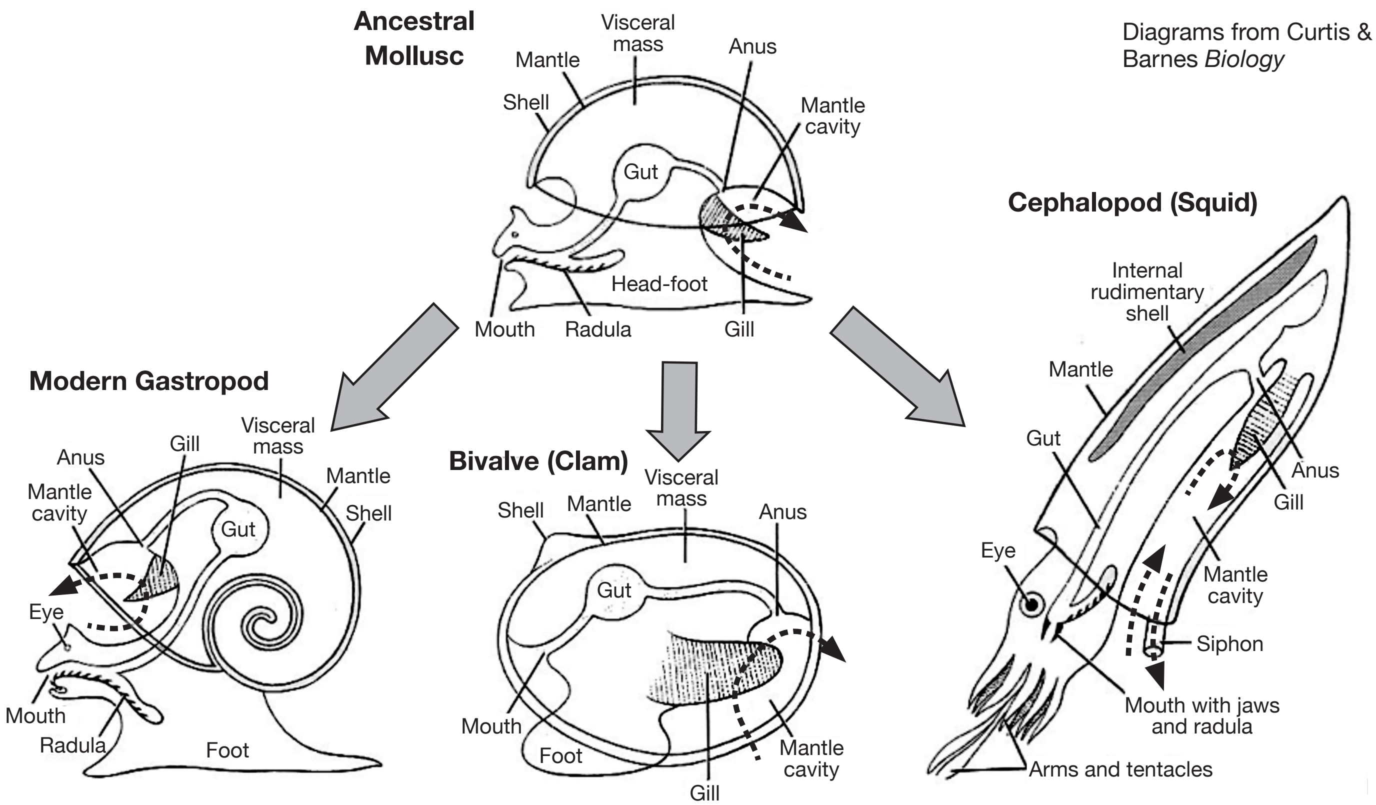

Diagrams from Curtis & Barnes *Biology*

The First Snail: A Worm with a Beach Umbrella?

Picture an ancient worm-like animal crawling on a shallow seafloor of the Precambrian ocean some 600 million years ago. Back then, the sun's ultraviolet radiation was quite ferocious, because Earth's atmosphere was still poor in oxygen and the ozone layer very thin. Over evolutionary time, some of these ancient creatures evolved a hard, calcareous dome, perhaps to shield them from the sun – like a beach umbrella! Or maybe it was to fend off predators. Either way, this animal was similar to the ancestral mollusc diagrammed above.

But notice that in modern gastropods, the beach umbrella shell of the ancestral mollusc has become coiled. Also, the mantle cavity has swung around 180° to the anterior end. ***What might be the benefit of these changes?*** (Hint: how did your live snail react when you handled it?)

Clams use their foot to burrow into the seafloor for safety. The beach umbrella shell has turned into a tightly closing hinged box, with a wedge shape to make burrowing easier. Clams quietly filter food from the water. ***What ancestral body features have they lost? Why?***

In squid, on the other hand, the shell has actually moved INSIDE the body. It has become lightweight and supports a long, streamlined body. ***What does this tell you about the squid's new lifestyle, versus its sluggish ancestors?***

The squid is in fact an active predator. It no longer crawls on the seafloor, but instead uses jet propulsion for fast swimming and hunting fish in open water. ***Besides the shell, what other features of the ancestral mollusc have changed for this new niche? Why?***

Why was there such pressure for so many different Why was there such pressure for so many different types of mollluscs to evolve?

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Divergent Evolution

Again, the snail, clam, and squid represent a case of **divergent evolution**, or what Darwin called "descent with modification." Their similarities show that they share a common ancestor, but their differences show that their bodies later adapted for new functions, new habitats, and new lifestyles as new challenges arose. In future lessons, labs, and episodes of *The Shape of Life*, you may learn about other molluscan specializations. There's the small but deadly blue-ringed octopus, whose bite delivers one of the world's most toxic venoms. There are cockles that use a giant, twirling foot to spring from their burrows and scramble away from attackers. There's the nautilus – half squid, half snail – that floats itself off the seafloor by filling its chambered shell with gas. As you learn about such amazing animals, bear in mind that they all came from the same ancestor: a simple snail beneath a beach umbrella!