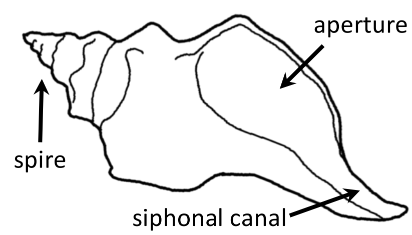
Shell Shocked

Lab Activity: Snails vs. Shell-breaking Predators

Few things in nature are as beautiful and fascinating as seashells, with their graceful spirals, marvelous shapes, and dazzling colors. However, the handsome homes of snails are built only at great cost. Creating a shell requires a huge investment of energy and building materials, so there must be a big payoff for the snail. That payoff, of course, is protection. Snails build their expensive shells not for beauty, but for a darker function: to defend their soft bodies against the sharp claws of hungry crabs and lobsters, and the strong jaws of predatory fish.

Here are some good shell designs and traits for thwarting predators:

- **Thick walls**: Heavy armor is the most basic defense, but costly to build.
- **Spikes, spines, and other protrusions**: These are a less expensive way to keep the claws and jaws of predators at a safe distance from the snail's soft body. And they make for an uncomfortable mouthful.
- **High spires:** Most snails create a twisted shell. Sometimes this is a "flat" coil shaped like a roll of Scotch tape or a fire hose rolled onto a spool. But others spiral out to a tall, sharp point resembling a soft-serve ice cream cone. The latter are harder to swallow and also add distance between attackers and the wide part of the shell where the snail lives.



- **Narrow aperture:** The shell's opening – or **aperture** – is the place most vulnerable to attacks. A slender, slit-like opening is tougher for predators to infiltrate than a wide, oval one.
- **Long siphonal canal:** Some snails do have a wide, oval aperture instead of a narrow one. Such snails usually also have a hard **operculum**, an oval "door" that seals across the opening whenever the animal retreats inside. However, this door also prevents the snail from breathing. Consequently, these snails have a **siphon**, a slender snorkel that pokes out and draws in water and oxygen. The snail extends its siphon through a tight **siphonal canal** in the shell. A long canal is less vulnerable to entry by predators than a short one. It also lets the snail burrow to safety without suffocating: Most of the animal remains safely buried, with only the siphon and siphonal canal raised into the water for breathing.
- **Thickened margins:** The outer rim or "lip" of the aperture is especially vulnerable to the shell-breaking grip of attackers. The thicker the better.

Study the armor from different species of gastropods. Grade each one (A, B, C, D, F) on each of the six defensive traits and fill out the report card.

Seashell Report Card

Species	Thick Shell	Protrusions	High Spire	Narrow Aperture	Long Siphonal Canal	Thickened Margins	GPA

Who's the valedictorian (top of the class)?

The salutatorian (2nd highest)?

Sweat hogs (bottom of the class)?

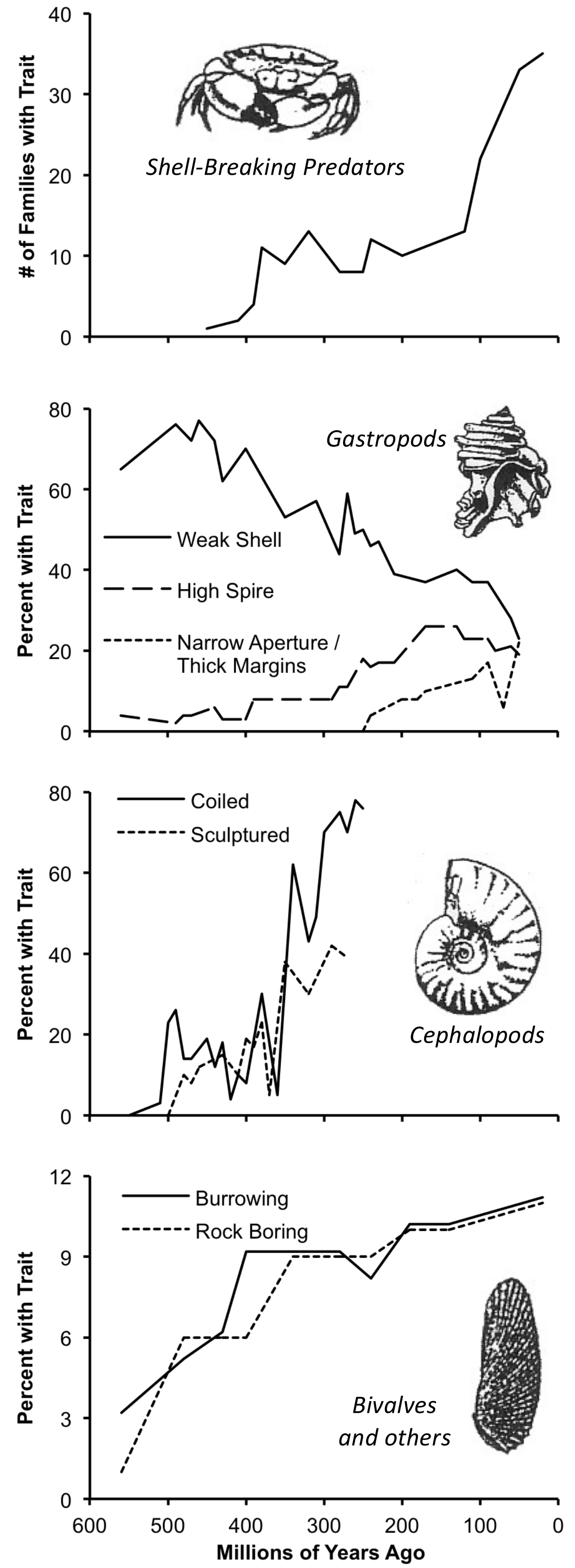
Class clown (weirdest)?

Homecoming queen (purtiest)?

One nice thing about seashells is that they preserve well as fossils. So do the hard claws, jaws, and teeth of shell-breaking predators. Geerat Vermeij (say "ver-MAY") is probably the paleontologist who has done the most careful surveys of fossilized seashells. His renowned studies are especially remarkable because he's been blind since birth. He collected all his data (tons of it) by studying the fossils with his hands!

The graphs to the right show data from Vermeij's research.* All four graphs share the same x-axis at the very bottom: He studied fossils spanning over 500 million years! Analyze the graphs carefully and answer these questions:

The top graph shows the number of fossilized predators that had claws or jaws powerful enough to break seashells. *How long ago did predators first develop shell-breaking traits? Since then, what has happened to the frequency of these traits in the fossil record?*



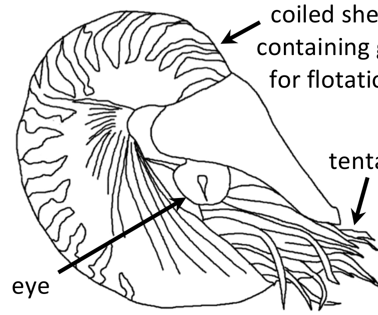
The next 3 graphs show 3 different groups of soft-bodied, shell-making animals (**molluscs**). **Gastropods** were snails that crept on the seafloor. **Cephalopods** were close relatives of snails, but many actually became swimmers: By collecting gas inside their shells, they could float above the seafloor and swim! **Bivalves** were also close relatives of snails, but with two hinged shells that open and close like the box that holds a wedding ring. Modern bivalves include clams and oysters.

Over the past 500 million years, what gradually happened to the design of gastropod shells?

*Adapted from Vermeij, G. J. (1987). *Evolution and escalation: An ecological history of life.* As reproduced in Endler, J. A. (1991). Interactions between predators and prey. In J.R. Krebs & N. B. Davies (Eds.), *Behavioral Ecology: An Evolutionary Approach* (3rd ed.).

A coiled shell gives a soft animal a bigger space to retreat into. "Sculptured" shells have ribs and ridges that reinforce the shell, or bumps and spines that make it hard to swallow. For cephalopods, what pattern do we see in the fossil record?

(NOTE: On the graph it looks like cephalopods suddenly went extinct 250 million years ago. They didn't. The reason they disappeared from the fossil record is that they lost their hard shells. This enabled them to swim much faster, as we see in modern day cephalopods like squid and octopi. An exception is the chambered nautilus, which has kept its shell and sluggish lifestyle.)



Chambered Nautilus, a modern cephalopod

Some modern bivalves – like clams – burrow into the seafloor. Others – like oysters – do not. Over the past 500 million years, what trend do we see in such behaviors?

What do you think prompted all these changes in the bodies and behaviors of gastropods, cephalopods, and bivalves over the past 500 million years? Back up your hypothesis with evidence from the 4 graphs.