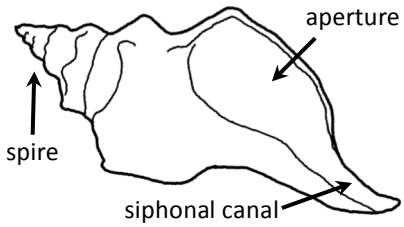
Shell Shocked

Lab Activity: Gastropods vs. Shell-breaking Predators

Few things in nature are more beautiful or more fascinating than the elaborately whorled, sculpted, and ornamented seashells grown by gastropods. However, as with all attractive real estate, the handsome homes of snails are built only at great expense. Manufacturing a shell requires a large investment of caloric and chemical resources …something natural selection would not allow unless there were a big payoff. That payoff, of course, is protection. The graceful beauty of seashells disguises their grim function: Their sophisticated shapes evolved for defense against the shell-breaking claws of crabs and lobsters, the shell-crushing jaws of fish, and the shell-drilling radulas of other snails.

Here are some good shell designs and traits for foiling would-be predators:

- **Thick walls**: Stout, heavy armor is the most basic defense, but costly to build.
- **Protrusions**: Spikes and spines, flanges and fronds, and prickly thorns are a more economical way to keep the claws and jaws of predators at a safe distance from the central cockpit where the soft snail resides. 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)?

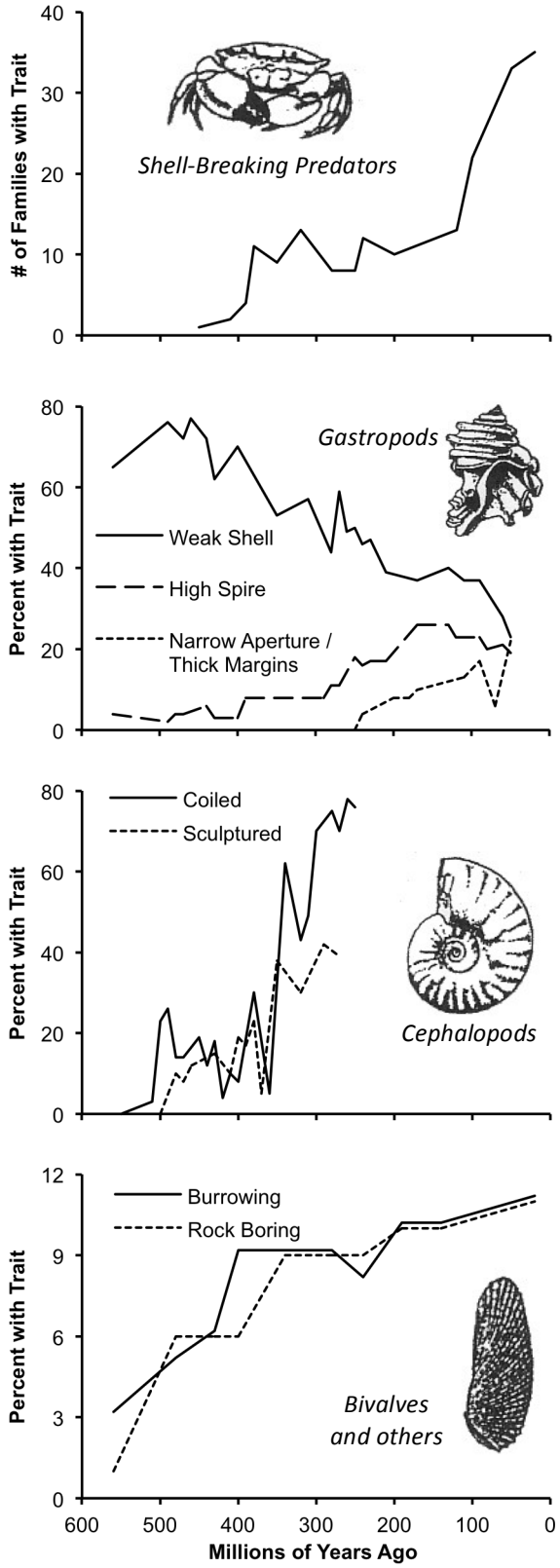
Class clown (weirdest)?

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") of the University of California at Davis is probably the paleontologist who has done the most careful and thorough surveys of fossilized shells. 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!

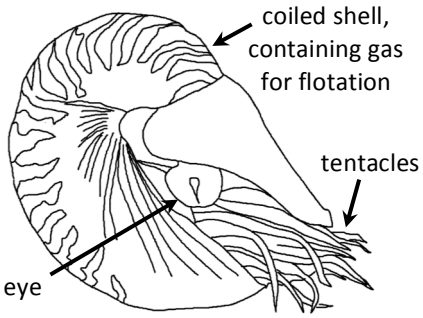
The graphs to the right show data from Vermeij's research.* All four graphs share the same x-axis at the very bottom: He studied fossils spanning over 500 million years! Analyze the graphs and offer a thorough, thoughtful interpretation of Vermeij's results. Write your answer on the next page as a meaty paragraph in complete sentences. A good answer will describe the long-term trends for all 4 groups of fossils and propose an explanation for them. What do you think prompted the changes? Back up your ideas with evidence from the 4 graphs. Here are some hints to help you compose your answer:

- **Gastropods** were snails that crept along the seafloor, foraging for food.
- **Cephalopods** were close relatives of snails, but many became swimmers: By collecting gas inside their shells, they could float above the seafloor and swim! 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. (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, evolving from slow, armored swimmers into soft-but-speedy predators, including modern day



*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.).

squid and octopi. An exception is the chambered nautilus, which has a squid-like body with eyes and tentacles, yet has kept its coiled shell and sluggish lifestyle.)



Chambered Nautilus, a modern cephalopod

- **Bivalves** were also close relatives of snails, but with two hinged shells that open and close like the box that holds a wedding ring. Some modern bivalves – like clams – burrow into the seafloor. Others – like oysters – do not.
- One of the "big patterns" we often see in evolution is a phenomenon known as **coevolution**. (Other patterns include divergent, convergent, and parallel evolution.) Coevolution occurs when different species adapt to EACH OTHER, back-and-forth, reciprocally. In other words, they impose natural selection on each other. How does Vermeij's data exhibit this phenomenon? (Hint: think of an "arms race.")

<u>Your Answer (paragraph form with complete sentences, please)</u>: