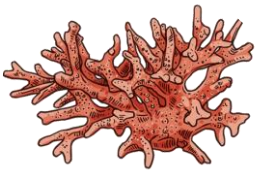
Dissolving Shells

Ocean Acidification & Naked Eggs

As our oceans absorb more carbon dioxide (CO_2) from the atmosphere, they become more acidic and the availability of carbonate ions (CO_3^{2-}) decreases. These ions are used by animals like snails, clams, sea stars, corals, and crabs to build calcium carbonate ($CaCO_3$) shells or support structures. In this experiment, you will explore how extended exposure to acid affects calcium carbonate shells.



Suggested Age - High School

Guiding Questions -

- How many animals can you think of that have calcium carbonate shells?
- How are these animals important to marine ecosystems and humans?
- Why does increased ocean acidity decrease available carbonate ions?
- What happened to your egg (or shells)? How would this treatment affect a living creature with a shell?
- What characteristic do shells have that causes them to react with acids?
- How does the acidity of the vinegar compare with that of ocean water? Does this change how you interpret your results?
- What kind of impacts might increasingly acidic oceans have on animals?
- What can be done to counteract the effects of ocean acidification?

Materials -

Small container (like a mug or bowl), distilled white vinegar, egg, large spoon, seashells (optional)

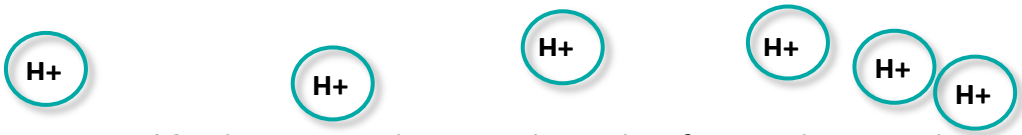
Activity Instructions -

- Place your whole egg in the shell (and seashells if using) in your container, and add enough vinegar to cover. *Do not crack open the egg.*
- Observe the container for a few minutes. Do you notice anything happening yet?
- Place the container in the refrigerator for 24 to 48+ hours. Position it somewhere out of the way. Check periodically to make observations. To speed up the process, gently pour off the vinegar after the first day and replace with fresh vinegar.
- After the treatment is over, gently lift the egg into a clean container using a large spoon. Discard the used vinegar.
- What are your results? How did the vinegar change your egg (and shells)? Why do you think this happened?

Extensions -

- **Are all ocean plants and animals impacted negatively by ocean acidification?** List as many ocean organisms as you can, and try to decide which would be negatively or positively impacted by more acidic oceans, or increased dissolved CO_2. Hints: Which organisms need CO_2 to grow? Which organisms consume animals with calcium carbonate shells? What other roles do shelled animals play in their ecosystems?
- **The naked egg is a good model for a cell.** Extend the experiment by exposing your "cell" to another type of liquid. Place your naked egg in a different solution and leave it for another 24 hours. Good options include: distilled water, saltwater, corn syrup, and water with food coloring. What happened to the egg? Did it change size? Do you think anything passed through your egg's "cell membrane?" Which direction was the movement (into or out of the egg)? Why?
- **Bounce your naked egg!** If the membrane around your egg is strong enough to handle, then why not see if your egg can bounce? Outside or in the kitchen sink, place a flat surface, like a baking pan. Hold a ruler vertically in the pan, and drop your egg from different heights to see how high it can drop from without breaking. Start at about 3 inches, and go up from there. How high can you go before your egg bursts instead of bounces?
- **Try it with a chicken bone!** Repeat the same procedure above with a chicken bone. How long does it take for the vinegar to change the bone? How do the results compare to the egg or the shells? What are most vertebrate bones made of?

Extra Information -



- **How does ocean acidification work?** When H_2O and CO_2 combine, they form carbonic acid (H_2CO_3). Carbonic acid is a weak acid but still releases H+ (hydrogen) ions, like all acids. The pH scale describes the concentration of H+ ions. An acidic solution has a high concentration of H+ ions and a low pH value, between 0-7. A basic solution has a low concentration of H+ ions and a high pH value, between 7-14. The H+ ions given up by acids bond with other molecules; this is what causes the damage from strong acids. These H+ ions also react with the carbonate ions in the ocean, making them unavailable to animals that use them in their shells.

- **The ocean has an average pH of 8.1, but is expected to drop to 7.7-7.8 in the next 100 years at the current rate.** This might not seem like a large change (7.7 is still basic, not acidic, after all), but because the pH scale is logarithmic, that is 200-250% as acidic as it is today. This means there will be 2-2.5 times the number of H+ ions in the water.