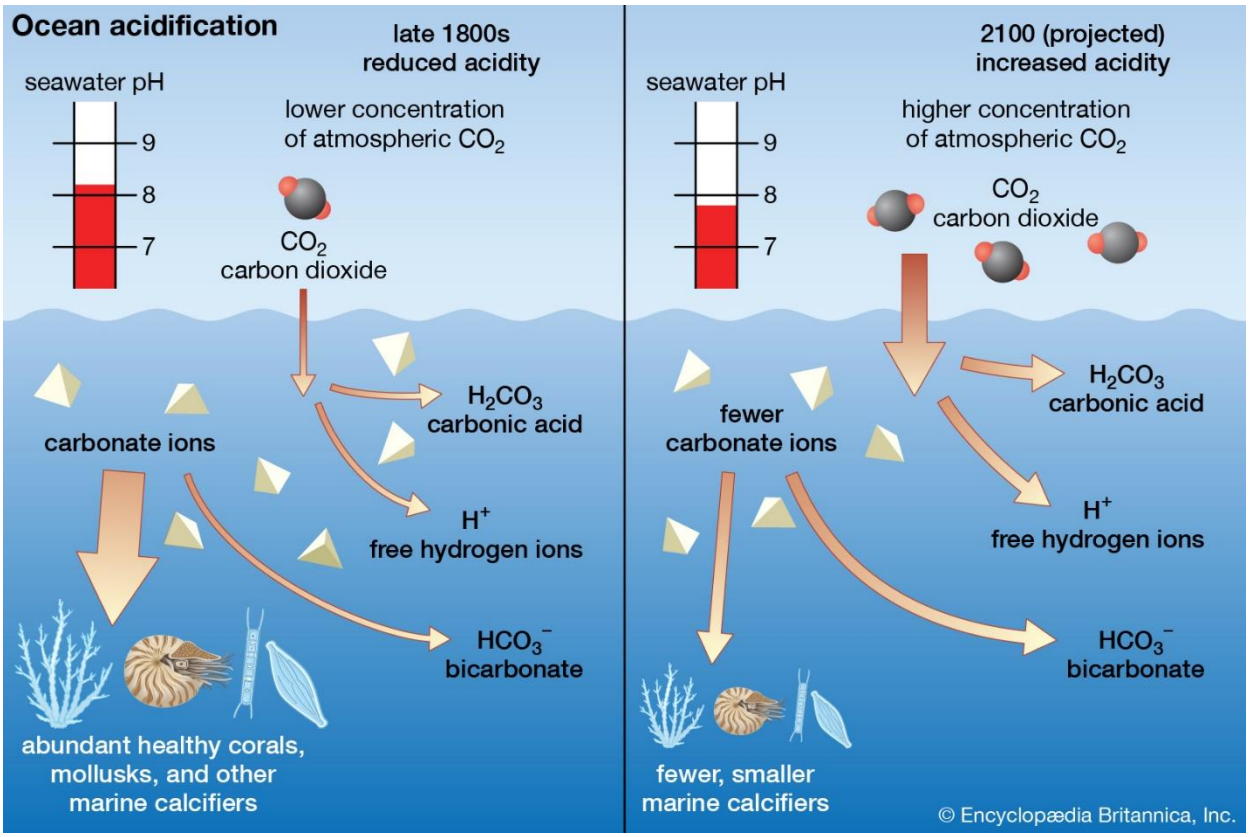
Ocean Acidification in a Cup:

Learn how things like carbon dioxide in the atmosphere make our oceans more acidic, even right here on Nantucket!



This activity illustrates how the diffusion of a gas into a liquid can cause ocean acidification. It also models part of the short-term carbon cycle—specifically the interaction between our atmosphere and the ocean's surface.

Mixing vinegar and baking soda together in the paper cup creates carbon dioxide gas (CO_2). The CO_2 gas then *diffuses* into the liquid below. When CO_2 gas diffuses into water, the following chemical reaction takes place and results in carbonic acid (H_2CO_3):

CO_2 (aq) + $H_2O \rightarrow H_2CO_3$

Carbonic acid dissociates into H^+ and HCO_3^-. The increase in H^+ causes the solution to become more acidic.

Carbonic acid is a weak acid. Even so, the presence of this acid affects the pH of the solution. Thus, after a short time, the surface of the indicator solution changes color: from purple to pale pink if you're using cabbage-juice indicator. This color change indicates a pH change caused by the diffusion of CO_2 gas into the liquid.

Outside of your paper cup, on a much larger scale, atmospheric CO_2 diffuses into the oceans. Oceans are the primary regulator of atmospheric CO_2. Human activities such as burning fossil fuels and changes in land use have increased the amount of carbon dioxide (CO_2) in the atmosphere from 540 gigatons of carbon (Gt C) in pre-industrial times to 800 Gt C in 2015.

How could more acidic ocean water affect Nantucket? Think about shell builders, like scallops, who need calcium and prefer more basic (rather than acidic) waters to form their shells. What other creatures could have weaker shells due to ocean acidification? Can you think of any plants or animals that could benefit from a more acidic ocean?

Materials:

- Safety goggles
- Homemade cabbage juice acid base indicator (instructions below!)
- Two clear 10-oz plastic cups (the tall ones)
- Paper cups, 3-oz size (you'll only use one in the experiment, but keep a few extras at hand just in case)
- Masking tape
- Plain white paper
- Permanent marker
- Baking soda
- White vinegar (baking soda produces CO2 gas when mixed with vinegar, simulating the atmosphere in our experiment)
- Two Petri dishes to use as lids for the plastic cups (or any clear plastic cover you have on hand. Saran wrap works too!)
- Graduated cylinder or measuring spoons
- Gram scale or measuring spoons

Creating Cabbage Juice Indicator at Home:

Take a quarter of a head of purple cabbage, place it in a blender with water to cover, and blend until you get a uniform puree. Strain the resulting mixture—the purple liquid you're left with is your cabbage-juice indicator. Dilute it with some water and proceed with the experiment. You will need to experiment with the ratio of water to cabbage juice to see what dilution gives you good results. Cabbage-juice indicator turns pink in the presence of an acid.

Carrying Out the Experiment:

1. Put on your safety goggles.
2. Pour 1 1/2 fluid ounces (40–50 mL) of cabbage juice indicator solution into each of the two clear plastic cups.
3. Add 1/2 teaspoon (2 grams) of baking soda to the paper cup.
4. Tape the paper cup inside one of the clear plastic cups containing the indicator solution so that the top of the paper cup is about 1/2 inch (roughly 1 centimeter) below the top of the plastic cup. Make sure the bottom of the paper cup is not touching the surface of the liquid in the plastic cup—you don't want the paper cup to get wet. The second plastic cup containing indicator solution will be your control.
5. Place both clear plastic cups onto a sheet of white paper and arrange another piece of white paper behind the cups as a backdrop (this makes it easier to see the change).
6. Carefully add 1 teaspoon (about 5-6 mL) of white vinegar to the paper cup containing the baking soda. Be very careful not to spill any vinegar into the indicator solution. Immediately place a Petri dish over the top of each plastic cup.

7. **BONUS:** Prepare an extra cup of cabbage juice indicator- blow into the indicator as fast as you can with a straw. Your own breath, containing CO2, will begin to change the acidbase indicator!

Special thanks to the Exploratorium Teachers Institute for original experiment design!