'A Tale of Two Acids' Demonstration Protocol

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You will need:

- **pH indicator solution** (prepared by boiling a few cabbage leaves in 1-2 cups water; allow to steep until cool, then strain)
- **3 clear plastic cups**
- **A pitcher of water** (~1 liter; you can use seawater, but tap water is fine)
- **1 drinking straw**
- **1 lemon or lime** (plus a knife to cut it with)
- **(optional) a pH scale graphic** (such as the animated slide of the pH scale in the 'Simple OA Demos…' presentation)

Background:

The purple solution prepared by boiling red cabbage is an inexpensive nontoxic pH indicator that you can prepare at home. Red cabbage contains high levels of a pH-sensitive pigment called anthocyanin (http://en.wikipedia.org/wiki/Anthocyanin). At the slightly basic pH of seawater (~pH 8.1) or tap water (typically between pH 7 and 8), anthocyanin is dark blue; as the pH declines, it gradually turns pink. The change that occurs when lemon juice (~pH 2) is added is dramatic; CO_2 has a much more subtle effect. Other pH indicators, like bromothymol blue, are quite sensitive to CO_2, and should *not* be substituted for the cabbage indicator in this demonstration, which is designed to illustrate the following points:

1. Ocean acidification does *not* mean that the ocean is becoming acid*ic* (i.e. pH below 7) like lemon juice;
2. The reduction in seawater pH caused by human-generated CO_2 is much more subtle, ~0.1 pH units on the open ocean surface; 0.5 to 0.7 pH units in the most severely affected regions;
3. Nevertheless, this relatively small decrease in pH can still have a significant impact on living organisms (illustrated in the subsequent 'Hold Your Breath' activity)

It is helpful to be able to refer to a graphic of the pH scale during this demonstration. The PowerPoint file titled 'Simple OA Demos slide deck' includes an animated slide of the pH scale slide that you can use for this purpose.

Set up:

Dilute ~1 cup of cabbage solution into 3 cups of tap water (you can use seawater, but it isn't necessary). Distribute the solution into three clear cups. Set one cup aside

as your 'control' (no pH change). The second cup will be acidified with lemon juice, the third with carbon dioxide.

Narrative:

"Many people hear the term "ocean acidification", and think that it means seawater is becoming acid*ic*. They imagine that it won't be safe to swim, because seawater will burn their skin. This is definitely *not* what's going on. The ocean is—and will remain—basic (pH > 7.0), because it is buffered by dissolved minerals. But ocean acidification *is* causing the pH of the ocean to decline. Since humans began burning fossil fuels and adding carbon dioxide to the atmosphere and ocean, the pH of seawater has shifted from 8.2 to 8.1. A change of 0.1 pH units may not *seem* like much, but because pH is measured on a logarithmic scale (similar to the Richter scale), what this actually means is that the oceans are 30% more acidic than they used to be."

"We're going to use this non-toxic pH indicator made from red cabbage to see what pH change looks like." Hold up your concentrated bottle of purple cabbage solution. "I've diluted this solution into seawater/tap water, and distributed it into these three cups" Hold up the lemon and ask the audience to identify it. "As we all know from experience, lemon juice is quite acidic." Point to lemon juice at pH 2 on the pH scale. "Watch what happens when we add lemon juice to this cup of seawater/tap water." Cut the lemon, then have a volunteer squeeze a few drops of juice into the second cup and swirl until a dramatic color change occurs.

"Your breath is full of carbon dioxide; we can simulate ocean acidification by bubbling carbon dioxide into this cup with this straw." Have a volunteer blow through the straw into the third cup, and ask the audience to tell them to stop when they think they see the color changing (it's a good idea to hold something under this cup to catch spills). Though the volunteer may blow for some time, the color change will not be nearly as dramatic as it was with lemon juice. However, if you hold a sheet of white paper behind the third cup and the control, everyone should be able to see that the cup acidified with CO_2 is *slightly* pinker. "Now, you may think this demonstration didn't work, but it actually showed you exactly what I wanted it to. You can see by the color difference that acidification caused by carbon dioxide is much more subtle than what people imagine when they think of "acid" (hold up the lemon). Nevertheless, it can have a *profound* effect on living organisms." (segue to 'Hold Your Breath'….)