Ocean Acidification Lab

Objectives:

Students will measure and compare the acidity or alkalinity of everyday substances to develop an understanding of acids and bases. They will understand that substances with a high pH are basic, and substances with a low pH are acidic. They will observe how the addition of carbon dioxide (CO2) can change the pH of a solution and understand why increases in atmospheric CO2 are causing ocean acidification. Students will examine how acidic solutions effect clam shells and understand that different marine organisms are affected differently by changing concentrations of CO2 in the ocean.

Concept:

Concerns about the effects of increasing levels of atmospheric carbon dioxide on the climate are well-known. However, changes in atmospheric carbon dioxide can also have significant impacts on the pH of the ocean. Decreasing ocean pH, or ocean acidification, may change the ocean in dramatic ways. Some marine animals, like oysters and clams, may have trouble forming shells with decreases in ocean pH. Other animals, like crabs and lobsters, may actually be able to construct shells more easily if there is a higher concentration of CO2 in the ocean. Scientists do not fully understand what organisms will be affected and how. This is definitely an area where more research is needed to better understand the processes, effects, and steps that can be taken to mitigate or adapt to ocean acidification.

Materials:

- Science notebooks
- Pencils
- pH test strips
- Eye droppers
- Beaker
- pH meter
- Sample bottles with the following substances:
    - Soapy water
    - Mountain Dew
    - Baking soda in water
    - Vinegar
    - Lemon juice
    - Ocean water
- Purple cabbage
- Water
- Blender
- Graduated cylinders
- Straws
- Floating candles
- Lighter/matches
- Aluminum foil or plastic wrap
- Calcium based shells and products
    - Clam, mussel, or oyster shells
    - Clean pieces of egg shell
    - Small pieces of chalk
    - Tums/Antacid tablets
- Permanent markers
- Laboratory scale
- Handout: 20 Facts About Ocean Acidification
- Handout: "Ocean Acidification: A Risky Shell Game" Article
- Handout: Acid/Base Lab
- Handout: Make Your Own Acid Ocean Lab
- Handout: Changing Shell-ters Lab

Preparation:

Pour solutions (lemon juice, baking soda in water, etc.) into sample bottles. Place an eyedropper with each solution.

Combine cabbage leaves and water in a blender. For every 2 cups water, add 1 large leaf from a red cabbage. You should plan on making at least 1 cup of indicator for every 2 students. Liquefy well in the blender. Pour the purplish cabbage liquid through a strainer to filter out all of the

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big chunks of cabbage. This liquid is your cabbage indicator. You may create this cabbage juice indicator ahead of time, or let your students help you make it. You may also choose to skip the cabbage juice altogether and use a universal pH indicator solution.

Make copies of the student directions for each experiment. You will need one copy per group.

Make 1 copy per student of "20 Facts About Ocean Acidification" compiled by scientists at the Ocean Carbon and Biogeochemistry Project, United Kingdom Ocean Acidification Programme, and European Project on Ocean Acidification.

Introduction:

Ask students what an acid is. Brainstorm a list of acids on the board. What happens when something is a really strong acid?

Then make a list of bases. What happens when something is a really strong base?

Show the students the pH scale and explain that pH is a way to compare how strongly acidic or basic something is. If something is measured as "1" it's the strongest possible acid. If it's measured as "14" it's the strongest base. In the middle scale, it's neutral, neither acid nor base.

Explain that the pH of a substance can be measured using pH paper, which will change color depending on how strong an acid or base the substance is. With pH paper, the color of the paper is matched to a color table that tells the pH number.

For older students, explain that pH measures the concentration of OH-ions in the water. If the ratio of OH- to H+ ions is high, the higher the pH and more basic the solution is. Conversely, if the ratio is reversed and there are many more H+ ions than OH- ions, the pH will be lower and the solution more acidic.

Activities & Procedures:

Explain to students that they are going to begin by exploring the pH of some everyday substances.

Show them how to use the pH strips. Take a strip out of the pH tube. Use the eyedropper to place a small amount of the sample on the pH strip. Then compare it with the color scale on the pH tube. Explain to students that because the strips are somewhat expensive, they should try to do 3-4 tests on different parts of each strip.

Divide students into groups of 2-4. Give each group of students a tube with pH color scale on it and some pH test strips inside.

Using the Acid/Base Experiment directions, have students complete the experiment and record the data in their science notebooks.

Now, explain to students that as carbon dioxide mixes with seawater, the seawater becomes more acidic.

Pass out the "20 Facts about Ocean Acidification" hand out.

View one or more of the following videos: "The Other CO2 Problem" created by Ridgeway School students (http://www.youtube.com/watch?v=kvUsSMa0nQU), "The Other Carbon Dioxide Problem" from NOAA (http://www.youtube.com/watch?v=9EaLRcVdTbM&feature

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=plcp&context=C3e90417UDOEgsToPDskIwJ4 8wUmUO5v_6iiHjBNqk), "Acid Test" from the National Resource Defense Council (http://www.nrdc.org/oceans/acidification/aboutthefilm.asp), or "Making Waves: Ocean Acidification" from NOAA (http://oceanservice.noaa.gov/podcast/p0513.html).

Conduct Experiment #2 using the "Make Your Own Acid Ocean" student directions. For this experiment, each group will need a beaker or cup with cabbage juice and each person will need a straw.

Ask groups to share their results after the experiment. What happened to the cabbage juice as CO2 was added? *(It became more acidic.)* Is this how CO2 enters the ocean in real life? *(Not really. It isn't directly injected into the ocean – like with the straw – but is instead mixed from the atmosphere. As CO2 levels in the atmosphere increase, more ends up in the ocean).*

Demonstrate the effects of increased atmospheric CO2 by placing a floating candle in a new beaker of cabbage juice.

As the candle burns, oxygen will be converted to CO2. Light the candle, and seal the top of the beaker with foil or plastic wrap (make sure it is far enough from the candle that the plastic wrap won't melt).

The candle will go out in a few seconds as it runs out of oxygen. Keep the container sealed so some of the CO2 can transfer to the cabbage juice.

Have the class observe any color changes in the cabbage juice.

After 30-60 minutes, return to the demonstration and use a pH strip or pH meter to measure the pH of the cabbage juice.

Discuss the results. How did the increase in atmospheric CO2 affect the pH of the cabbage juice?

Ask students to think about how changing ocean pH might affect marine organisms. Reflect back on the video(s) you watched earlier.

If you'd like, have students use this animation from the Woods Hole Oceanographic Institute to learn how animals build their shells: http://www.whoi.edu/page.do?pid=110417&cid=55243&cl=38052&article=52990&tid=5782

Divide students into groups of 4-6 to conduct experiment #3, "Changing Shell-ters" using the student directions.

Each group will need 6 petri dishes, 3 pieces of shell, and 3 calcium product and access to the sample solutions from experiment #1. You can have different groups test different types of shells and calcium, but they should be the same within the group.

This experiment works best if you can let the shells/calcium sit in solution for a few days, even up to a week or more. Store the petri dishes in a safe location and check on them periodically to make sure the solutions have not evaporated.

After the allotted days, have students remove shells/calcium to a paper towel to dry before weighing them on the scale.
After students have weighed them, discuss the results. *(Shells that were in strong acidic solutions should weigh a little bit less than shells in basic or*

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neutral solutions. Some of the calcium products may have dissolved significantly.)

Have students compare the pH of the solutions that caused thinning of the shells with the current pH of seawater and predicted pH of seawater. Many scientists predict an ocean pH of about 7.7 in one hundred years. Is this more or less acidic than the solutions the shells thinned in? *(Most of the solutions – vinegar, lemon juice – are significantly more acidic than the predictions for the ocean.)* Would they expect to see more or less dramatic results in the ocean? *(The results in the ocean would be less dramatic and immediate, but could still have major impacts on marine organisms.)*

Wrap-up:

Following experiment #3, or during the waiting period, have students read "Ocean Acidification: A Risky Shell Game." Ask students to discuss the article with a partner, focusing on what surprised them in the article and questions they have.

Discuss the article as a class. What types of animals will likely be affected the most by increased CO2 in the ocean? *(Those that build calcium shells).* What animals will be affected negatively? *(The research suggests animals like clams, mussels, and pteropods will be affected negatively.)* What animals will be affected positively? *(The research suggests that animals like crabs and lobster might be able to build exoskeletons more easily).*

Ask students to reflect in their science notebook about ocean acidification:

- What is ocean acidification?
- How will marine animals be affected?
- What can people do to mitigate or adapt to ocean acidfidcation?

Extensions & Lesson Connections:

This lesson can be extended with a virtual lab through Stanford University about the development of urchin larvae in acidic waters: http://virtualurchin.stanford.edu/AcidOcean/AcidOcean2.htm.

NOAA's data on ocean surface pH can be used for classroom investigations, http://dataintheclassroom.noaa.gov/DataInTheClassRoom/SitePages/oa/index#.Uu_8zvZRn6Q, and their Ocean Acidification simulator is a powerful tool to visualize the effects of different levels of atmospheric CO2 on various aspects of ocean acidification: http://dataintheclassroom.noaa.gov/DataInTheClassRoom/SitePages/oa/simulation.

Evaluation:

Check science notebooks for accurate and thorough observations and data collection from the experiments. Assess the student reflections for understanding and application of the main concepts. Evaluate student participation during discussions and cooperation during group work.

Acid/Base Lab

1. Take 1 pH strip out of the tube.

2. Use an eyedropper to carefully place 1 drop of a sample solution on the pH strip. Place the eye dropper next to the sample solution. Do not use the same eye dropper for a different solution!

3. Wait 30 seconds and compare the color to the color scale on the pH tube.

4. Decide what color is most closely matches the color of your test on the pH strip. Record the pH number associated with the color in your science notebook along with the name of the solution.

5. Use a different part of the pH strip to test a different solution. You should be able to fit 3-4 tests on each strip.

6. Work with your group to test all of the substances and record your findings. in your science notebook.

7. Discuss the following questions with your group and record your answers in your science notebook:
    - What was the most acidic?
    - What was the most basic?

8. Pour ¼ cup of the small amount of the cabbage juice indicator into 3 small beakers. Cabbage juice works like the pH strip, but you'll have to figure out for yourself what color indicates acid and what color indicates base.

9. Add 5 drops of the most basic solution (highest pH) to one of the beakers of cabbage juice and carefully swirl the beaker to mix. Note what happens to the color.

10. Add 5 drops of the most acidic solution (lowest pH) to a different beaker of cabbage juice and carefully swirl the beaker to mix. Note what happens to the color.

11. Arrange the beakers from lowest pH (beaker with acid added) to highest pH (beaker with base added). The beaker of cabbage juice should be in the middle. You will use this scale in the next experiment.

Make Your Own Acid Ocean Lab

1. Test the pH of the cabbage juice indicator with a pH strip or pH meter. Record the initial pH in your science notebook.

2. Use a watch, clock, or stopwatch to keep track of time during this experiment.

3. One person in your group should place their straw into the beaker of cabbage juice indicator and carefully blow. As the person exhales, they are releasing mostly Carbon Dioxide, which is being moved into the cabbage juice through the straw.

4. After about 10 seconds, rotate your source of CO_2. Have a different group member blow through their straw into the cabbage juice.

5. As you rotate through group members, keep an eye on the cabbage juice. At what point does the cabbage juice begin to change color? Record this time in your science notebook, but make sure a group member keeps blowing through the straw.

6. Continue blowing through the straw until it seems like the cabbage juice has stopped changing color. Record the time.

7. Compare your cabbage juice with added Carbon Dioxide to the cabbage juice color samples you created in the earlier experiment. Which sample is it closest in color to – the low, medium, or high pH?

8. Now check your results with a pH strip or pH meter.

9. Answer these questions in your science notebook:
    - Did the pH of the cabbage juice increase or decrease when CO_2 was added?
    - Does this match your color samples for cabbage juice?

Changing Shell-ters Lab

1. Weigh one sample of shell. Record the weight in your science notebook as "Sample #1" and put it into a petri dish that you label #1.

2. Do the same with Samples #2-#6. You will use a type of shell for samples #1-#3, and a type of calcium product for samples #4-#6.

3. Choose 3 solutions from experiment #1 – one that has a low pH (very acidic), one that has a medium-low pH (somewhat acidic) and one that has a pH around 7 (neutral).

4. Use the eye droppers to cover each sample with one of the solutions you have chosen. You should have a shell covered with very acidic solution in a petri dish, a shell covered with somewhat acidic solution in a petri dish, and a shell covered with neutral solution in a petri dish. You should have the same three samples for the calcium product.

5. Record in your science notebook the name of the solution you add to each shell and calcium product.

6. Cover the petri dish after you've added the solution.

7. Observe in your science notebook any immediate effects on the shell/calcium product in each solution.

8. Make a hypothesis in your science notebook about what will happen to each shell/calcium product as it sits in the solution.

9. Make another round of observations 30 minutes and 1 hour later.

10. When your teacher directs you, carefully remove the shells/calcium products from the petri dish and place them to dry on a paper towel. Make sure to label the number of each one on the paper towels.

11. Weigh them and record in your science notebook.

12. Answer the following questions in your science notebook:

- Do any shells/calcium products lose mass? If so, what solutions were they in?
- Look at your data from Experiment #1. What was the pH of the solutions that caused the shells/calcium products to lose mass?
- Why do you think some of the shells/calcium products lost mass?
- Which lost more mass – the shells or the calcium product? Why do you think that is?
- What might happen to shells in the ocean if it becomes more acidic?
- What animals do you think will be affected most by ocean acidification?