# Changing Ocean Chemistry

**Duration:**
1 class for set-up
Several weeks for monitoring, observing and recording
1 class for wrap-up and cleaning equipment

**Objectives:**
Students will:
- Grow *Artemia* sp. in several different habitat conditions
- Monitor growth and survival of the plankton

**Vocabulary:**
**Plankton**
Aquatic organisms unable to swim against currents, and therefore drift in the water
**pH**
Measure of $H^+$ ions in a solution; a measure of acidity
**Acidity**
The level of hydrogen ions present in a solution
**Calcification**
The process of growth where layers of calcium carbonate are laid down to form a hard surface, i.e. a shell

## *British Columbia PLO's:*
Science 6, 7, 8
Math 6, 7, 8

## *Background:*
Students will raise Artemia (Brine shrimp) in the classroom in a variety of pH levels. As the ocean's acidity increases it is thought that plankton that form shells will not be able to do so. Here students will test the ability of one type of zooplankton to develop and grow at different pH levels.

Plankton are drifters, riding the world's ocean currents. Plankton blooms in areas that are high in nutrients and are the bottom of the food chain, supplying many other marine organisms with food. They are sensitive to changes in water chemistry like temperature and pH, both of which are being altered with climate change. The pH and temperature of the water directly can affect an animal's respiration, digestion, and circulation, and thus their ability to survive and reproduce.

The pH scale is a measure of hydrogen ions in a solution which makes it acidic. The scale goes from 0 (very acidic) to 14 (very basic). Both extremes can be toxic to humans (most substances we use are near neutral at 7). Everyday solutions we use include lemon juice, which has a pH of 2.4, and domestic bleach, which has a pH of 11.

The genus Artemia is an ancient crustacean that has been on Earth for over 100 million years. They live in saltwater and, under stressful conditions, produce egg cysts that can live in a dormant state for up to 50 years. By placing them in the right conditions, the eggs will hatch and develop into adults. Ideal conditions include bright light, a temperature between 26-31˚C, and a pH of 8. They will grow and mature in 8-14 days and can live up to 4-5 weeks, though keeping them alive this long can be a challenge. In the classroom we can use these organisms to investigate how pH levels can affect zooplankton.

## *Materials:*
- *Ocean News* article *Plankton: doing more than drifting through*
- Brine shrimp cysts (*Artemia*)
- Large jars or beakers (min 9)
- Air stones and pumps (optional)
- Water (preferably distilled)
- Mercury-free thermometers
- Graph paper
- White vinegar
- Baking soda
- pH paper
- Measuring spoons
- Magnifying glass

## *Procedure:*

*In Advance*

1. You will need to buy some *Artemia* at a pet store, toy store, or you can also order online. They are commonly referred to as sea monkeys or brine shrimp. The kits from pet stores or pet food suppliers are most likely to work well as they are sold to be raised for feeding aquarium pets.

*In Class*

1. Read the *Ocean News* article *Plankton: doing more than just drifting through* with the class.
2. Have the students Think-Pair-Share about what they thought was the most interesting part of the article.
3. Ask the students to form a question about something they did not understand in the article. Ask students to share these questions with the class and address a few of them with everyone.
4. Discuss how plankton are specially adapted to living in the open ocean environment (feeding, reproduction, movement etc.).
5. If it has not already been taught, begin with a simple chemistry lesson on pH and acidity. The students should be able to understand the differences between acidic, basic and neutral substances, and where most things live and grow. Give the students' examples of everyday solutions and where they fall on the pH scale (see the resource section).

*Experimental Set-up*

1. Review the experimental set-up with the class. You can use the power point schematic as an overhead to help explain.
2. To set-up the jars for the experiment, you can divide the students into small groups or work with the entire class. You want a minimum of three replicates of each condition (for a total of at least 9 jars). For small classes you can have partners setup one jar of a certain pH and with the class you end up with the entire experimental design of 9 jars. You can then take all the data from across the class to analyze. In the end, the experimental design will depend on class size and equipment availability.
3. Set-up different beakers according to the directions given with your *Artemia*. Follow the instructions on the packages to bring the water to the standard growing conditions; you may have to add some water neutralizers and let the water sit for 24 hours. You may want to do this before class to speed along the process.
4. Tape a transparent ruler to the outside of each jar to help with making size estimates later.

*Next Day*

1. Once the jars of neutral water are set-up we need to create the pH groups. We want to test neutral water and two levels of acidic water. The groups who are doing the two acidic treatments will add the vinegar. Test the treated water with pH paper to establish the standard pH. Once you know what the package calls for, you ideally want to decrease the pH to 1 and 2 units below normal. A teaspoon of vinegar in 2 cups of water with a pH of 7 will give you a pH of roughly 6. Depending on your volume, add enough to drop the pH about 1 unit (if you go much lower than 2 units the *Artemia* are not likely to hatch).
2. When the pH has been established, add the *Artemia* cysts to the water. The cysts are very small and can be difficult to count precisely. If you have a details-oriented class, have them count out equal numbers for each jar (approximately 30-40 eggs per jar). Alternatively, get the students to add a pinch of eggs. You can also personally dispense the eggs.
3. Place all the jars in a location with equally distributed bright light that is easily observable by the students over the next few days. The cysts will begin to hatch over the next 24-48 hours depending on conditions.

4. Have the students create an observation chart in their books that can be added to over the next week. They will be observing and recording what they see in their own jars (as well as observing other jars in a more informal way).
5. Have the students make predictions about what they expect to occur in the different jars. Have them formulate a hypothesis using the "If…then…because" format.

*Long-term*

1. Each day, have your students observe the *Artemia,* noting abundance and development in the morning and afternoon, recording observations in their notebooks. Have them count the number of individuals and their approximate size range using the transparent ruler that is taped to each tank (see the resource section for help with estimating percent cover). You may also want to set-up a simple magnifying glass to help students take a closer look. The *Artemia* cysts develop into small juveniles in 8-14 days.

*Wrap-up*

1. After about 7-10 days, or whenever the *Artemia* have hatched and are swimming, have the students do some final observations, both descriptive and qualitative. You can run the experiment longer, but adult *Artemia* are difficult to keep alive for much longer.
2. The groups should be able to do a final count of individuals that hatched. During the clean-up have the students remove the *Artemia* from the jars and count them. Once they are confident that they have counted all the *Artemia* present, have them clean the equipment and set it aside.
3. Examine one of the *Artemia* under a microscope and have the students sketch what they see. This can be handed in with their report.
4. Draw a table on the board with pH across the top and the jar numbers down the side to record the different measurements and calculate the class average.
5. Have the students create a bar graph examining the growth and survival of the *Artemia* at different pH levels, with the pH treatments along the x-axis and number that hatched (or survived till day 6) along the y-axis. Plot the data. Discuss the general tendencies and patterns.
6. Discuss with the students what they observed. Have them write a summary about what has occurred over the last several weeks in the jars and why.
7. As a formal report, you can have the students write this lab up to be handed in and graded.

*Temperature*

1. You can also alter the temperature and monitor the development of the *Artemia*. This can be accomplished by placing the beakers in different rooms around the school, although some prep work is needed for this. Place a few beakers of water in a few places and monitor the temperature for a few days to test where the beakers should be placed. These locations should be accessible by the students at least during certain times so that observations can be made.
2. Get the class to set-up the beakers in the same way following the instructions for the *Artemia* that you have purchased. Tape a transparent ruler to the outside of each jar to help make size estimates later. Place three jars at each of the temperature locations and monitor them.
3. Let the *Artemia* develop for 7-10 days with the students make observations and entries in their notebooks.
4. As before, at the end of the experiment, the students should count all the individuals that developed and analyze the class data.

5. Have the students make predictions about what they expect will happen in the different jars. Have them formulate a hypothesis using the "If…then…because" format.

*pH and Temperature*

1. Ideally, we want to test temperature and pH as both are changing rapidly with global warming. This requires setting up different pH jars at different temperatures.
2. Again, follow the initial set-up instructions given with your particular *Artemia* cysts. Tape a transparent ruler to the outside of each jar to help with making size estimates later.
3. As was done with the temperature only set-up, establish where jars can be placed to keep them at constant temperatures.
4. After establishing what the starting pH is, decide what acidity levels the class would like to test. Try to have the neutral jar plus two other pH levels.
5. Take jars with each of the pH levels to the different temperature locations where they can be easily observed.
6. Have the students create their observation charts and begin entering their comments and observations over the next several days.
7. Have the students make predictions about what they expect will happen in the different jars. Have them formulate a hypothesis using the "If…then…because" format.
8. At the end, have the students record the number of *Artemia* and do some analysis of class data.

## *Discussion:*

- How does vinegar mimic pH changes in the oceans caused by global warming?
- What do *Artemia* feed on, and what feeds on them?
- What happened to the *Artemia* that were raised at lower pH levels?
- How does this experiment mimic what is happening in the world's oceans?
- Why is it important to test both temperature and pH at the same time in order to better understand what is happening in the oceans?
- What would happen to the ocean's ecosystems if shell-bearing plankton were unable to form?
- Make a list of the animals that will be impacted by reduced plankton in the oceans. How many of these will impact your life? How many of these will impact humans around the world?
- How do plankton species alter their environment?

## *Extension and Resources:*

- See the experimental setup PowerPoint document for assistance with lab set-up.
- For more basic treatments add some baking soda to the water in small amounts to get a desired pH value of roughly 9-10.
- You can find examples of commonly used solutions and their pHs at this website: www.phmeters.com/basic_ph_tutorial.htm
- Wikipedia provides a good explanation of what pH is: http://en.wikipedia.org/wiki/ph
- *Artemia* information and images can be found at: www.captain.at/artemia/
- Tips for raising successful *Artemia* www.seahorse.org.library/articles/artemia.shtml
- A good website for information on ideal *Artemia* growing conditions can be found at: www.fao.org/docrep/field/003/AC062E/AC062E03.htm
- Good percent cover estimate images that can be used and come with an explanation are available at: archive.orr.noaa.gov/shor_aid/chart.html
- The Ocean News Changing Currents article and lesson plan compliments this activity and could be done in one class during the running of this experiment to expand on ocean conditions and how they affect marine organisms.

*Risk management:*
All labs should use proper equipment. All the materials in this lab are household items and are not harmful, but this lab can be used to practice and reinforce good experimental procedures and practices. Gloves and goggles should be used by all students.