WRAP-UP

To wrap-up the investigation, bring your students together for a group discussion to help them understand why and how they achieved their results. It is important to share results so that everyone has a clear picture of what happened. To help you facilitate the discussion, review the explanation in "The Why and The How" using the Group Discussion questions as a guide.

GROUP DISCUSSION

Explain to students that scientists learn from each other through discussion, and they build upon the work of others to make new discoveries. Just as scientists come to conclusions based on the findings of their experiments, students will now come together as a group to share their results and make conclusions about the investigations they've conducted. Have students record their final results and the explanation in their journals.

- What did you learn about water in this investigation?
- What surprised you?
- What new questions do you have?
- Where there any differences or similarities in seed growth?
- How can you explain any differences?
- What does this investigation tell you about pH levels and seed growth?
- How do you think acid rain affects plant growth?
- What evidence have you observed to support this?

The "Why" and the "How"

pH tablets are used to indicate the presence of acids and bases. Under acidic conditions, pH tablets will turn a solution red, and under basic conditions the solution turns green. Scientists use the pH scale to measure the strength of a solution. Acids have a pH range from 0 - 6, and basic solutions have a pH range from 8 - 14. Strong acids have a low pH between 0 - 4, while strong bases have a pH ranging from 10 - 14.

The seeds in the plain water dish have a neutral pH of 7 and should sprout in every group, growing an average of 6 cm. The pH of the acidic vinegar solution was approximately 5. The pH of the basic baking soda solution was approximately 8. The seeds in these solutions will have little or no growth.

Many substances dissolve in water. This is why water is often called a universal solvent. However, water does not reduce the effects of acids and bases. Acid rain is an abiotic element that can affect the pH of an aquatic ecosystem. Acid rain occurs when gases from the atmosphere (such as sulfur dioxide from coal-burning factories) fall to the earth in precipitation (rain, snow, sleet and fog). Acid rain washes into aquatic ecosystems, changing the pH levels of the water. Aquatic organisms are particularly vulnerable to acid rain because they spend all or part of their life cycle in the water. Many species of amphibians, fish and insects lay their eggs in the water. Changes in pH levels cause deformities in the young of aquatic organisms, or cause fish to produce weak or brittle eggs. Acids can also interfere with a fish's ability to absorb oxygen, salt and nutrients needed for survival.

During summer months, pH levels of a lake or stream will range between 7.5 and 8.5. Small, free-floating aquatic plants called phytoplankton produce much of the oxygen in aquatic ecosystems. They also serve as the primary food source for other aquatic organisms that cannot produce their own food such as fish and crayfish. Phytoplankton can thrive and provide a nutrient source for the entire aquatic ecosystem if the ecosystem can maintain a pH level at or above 6.5.

When the pH level of an aquatic ecosystem becomes lower than six, phytoplankton and other basic foods such as mayflies and stoneflies die. When the pH level is lower than 5.5, fish cannot reproduce and their young have difficulty staying alive. At this pH level, fish become affected by the lack of nutrients and may die of suffocation. When an aquatic ecosystem reaches a pH level lower than five, the entire fish population begins to die off. Most aquatic organisms cannot survive a pH level lower than 4.

Curriculum Match-Up

- Repeat Part 1 of this investigation using other materials such as salt, milk, apple juice, hydrogen peroxide, shampoo, soda and soapy water. Record your results.
- Design an experiment to test the effects of other pollutants on aquatic ecosystems. What would happen if an ecosystem had too much salt, for example?
- Draw a diagram showing where acid rain and other pollutants travel through the environment.
- Collect water samples from an aquarium or from local bodies of water and test their pH levels. What can these levels tell you about the organisms living in these environments?
- Look at the shampoo bottles at home or in the store. Why does the pH level of shampoo or the pH level in a pool need to be a certain level?
- Plant the sprouted seeds from this investigation and chart their growth.

References
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Water Quality and pH Levels in Aquatic Ecosystems

Learning Objectives

Students will:

1. Test and determine pH levels of liquid solutions.
2. Identify solutions of acid, base, and neutral pH using indicators.
3. Determine the optimal pH for the growth of plant seeds.

Vocabulary Ventures

abiotic
acid
acid rain
alkaline
amphibian
aquatic
base
biotic
ecosystem
electron
element
hydrogen
neutral
pH level
phytoplankton
run-off
viscosity

Aquatic ecosystems include ponds, wetlands, estuaries, streams, lakes and oceans. These ecosystems must maintain proper levels of **abiotic**, (non-living), elements in order for biotic (living) organisms to survive. Examples of abiotic elements include sunlight, water temperature, nutrient levels, dissolved oxygen and soil composition.

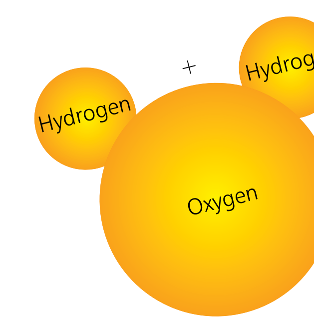
U. maritimus (polar bear)

Living organisms are highly dependent upon certain abiotic elements in every **ecosystem.** For example, a polar bear (biotic organism) is dependent on the cold temperature (abiotic element) of its environment for food, shelter and camouflage.

The **pH** levels of soil and water are important abiotic elements that affect the survival of many organisms. pH (potential hydrogen) level measures the strength of a chemical. pH is measured on a scale from 1 to 14 and tells how much hydrogen is found in a particular substance. Hydrogen is a naturally-occurring element and is one of the building blocks of Earth. You may remember that two **hydrogen** atoms combine with one **oxygen** atom to form a molecule of water.

Hydrogen is found in all living things. The amount of hydrogen makes a solution acidic or basic.

If you've ever used vinegar or baking soda, you're already familiar with acid-base chemistry. In this activity, you will observe the relationship between pH levels and living organisms.



the water molecule

Time Needed to Conduct Investigation

This investigation has two parts.

This Investigation will be done over a period of weeks.
Organize and set up materials: 10 minutes
Introduce the lesson: 10 minutes
Conduct the investigation: 20 minutes to start, 10 minutes each following week
Student journaling/group reflection: 10 - 15 minutes
Total estimated time: 55 - 65 minutes

Investigation: Understanding pH

Materials

For groups of two to four
Student journals and writing tools

Part 1
- Four 3 - 5 oz clear plastic cups or 50 mL test tubes
- Distilled water (approximately 13.5 tablespoons)
- Lemon juice (approximately 3.5 tablespoons)
- Baking soda solution (1 teaspoon of baking soda / 3.5 tablespoons of water)
- Vinegar
- pH wide range test tablets
- pH color chart

Part 2
- Three small plastic-coated plates or Petri dishes
- 24 corn seeds, radish seeds or lima beans
- Vinegar solution (1 cup vinegar / 1 cup water)
- Baking soda solution (1 cup of baking soda / 1 cup of water)
- 1-liter water sample (rainwater, tap water or water from a local pond or lake)
- Paper towel sheets (cut to fit the plates)
- 1-gallon clear plastic storage bags
- Ruler (cm)
- Permanent marker

Part 1
Acid or Base?

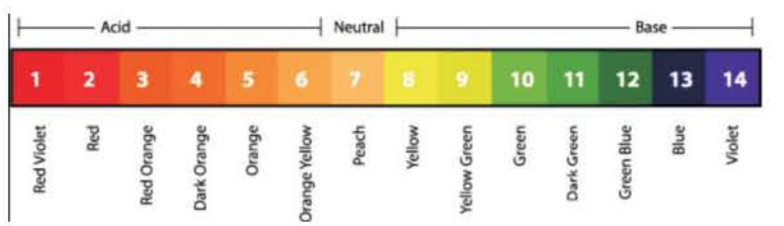
Tell students that they are going to test various liquid samples to determine their pH levels.

GET READY!

Share with students that all chemicals can be divided into three categories: acid, base or neutral. Ask students if they've ever tasted lemonade -- this is an example of an **acid**. Acids have a sour taste. The opposite of an acid is a **base**. Some common bases are baking soda, bleach and antacids such as Tums (for acid indigestion or "heartburn"). Water is an example of a neutral chemical because it is neither an acid nor a base.

The pH scale is used to identify acidic, alkaline (or basic) and neutral chemicals. The pH scale ranges from 0 to 14. A pH level between 0 - 6 indicates a higher concentration of hydrogen. Solutions with pH levels from 0 - 6 are considered **acidic.** The higher the pH level, the lower the concentration of hydrogen. Solutions with pH levels from 8 - 14 are considered basic, or alkaline. A pH of 7 is considered **neutral.**

pH Color Chart



Source: National Aeronautics & Space Administration

OBSERVE

Pour each of the four liquids into a different test tube. Ask students to examine the liquids and document the following observations in their journals:
- Use the "wafting method" (move your hand back and forth over the top of the test tube) to determine how each liquid sample smells.
- Describe the smell, color, viscosity (how easily it flows) and other physical properties of the liquid samples.

PREDICT

Have students predict the pH of each liquid sample and record predictions in their journals.
- Predict the pH level of each sample. Is it an acid, a base (alkaline) or a neutral solution?

PROCEDURE

1. Have students test the samples by dropping one pH tablet into each of the cups.
2. Have students compare the test tube with the pH color chart and record their observations in the chart in their journals.

Ask students:
- Was your prediction accurate?
- Is the liquid sample an acid, base or neutral?

ph Levels

	pH Prediction *(write the number)*	*pH Results*	*Acid, Base or Neutral?*
Distilled water			
Lemon juice			
Vinegar			
Baking soda & water			

Part 2
pH and Plants

Tell students that they will now observe how pH levels affect seed germination.

PREDICT

Ask students to predict what effect each solution will have on the seeds and document their predictions in their journals.
- What effect will the vinegar-water solution have on the seed? The baking soda-water solution? The plain tap water?
- Why do you think that is?

PROCEDURE

Inform students that they will place seeds in each solution and measure their growth rate.
1. Have students label the plastic storage bags vinegar/water solution, baking soda/water solution, and plain tap water using the permanent marker.
2. Next, students should place a paper towel onto each of the three plates.
3. Have students count out eight corn seeds and place them on the paper towel in each of the plates.
4. Next, have students pour plain water onto one plate of seeds until the paper towel is saturated.
5. Students should place the plate into the matching plastic storage bag and seal the bag almost completely, leaving room for air to circulate.
6. Have students repeat the process, pouring the vinegar/water solution onto one plate of seeds, and the baking soda/water solution onto the remaining plate of seeds.
7. Students should place each plate into the matching plastic storage bag and seal each bag almost completely, leaving room for air to circulate.
8. Have students place the seed plates near, but not directly under, a light source.
9. Students should check the seeds daily to see if any of them are germinating (sprouting or growing).
10. Check the seeds every week and measure the growth of any sprouts using a centimeter ruler.
11. Save the remaining solutions and keep the paper towels moist by refilling the solutions as needed – don't let the seeds dry out.

seed set-up

OBSERVE

Students should record their observations in the Seed Germination chart in their journals.
Ask students:
- Was your prediction correct?
- Did the seeds grow in each solution? Why or why not?
- What was the best possible pH for seed growth?
- How do the seeds look? Draw your observations in your journals.