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Teacher Notes

Changing pH Introduction

This activity is designed to be part of an ongoing investigation in which students are observing and investigating environmental conditions such as moisture, dissolved oxygen and carbon dioxide, temperature, sunlight, and acidity affect organisms, and how organisms interact.

It is not intended that students will understand pH on a molecular level. It is sufficient that they observe an environmental condition to which we have given the name pH or acidity. The goal of the activity is to expand their repertoire of experiences with and awareness of environmental conditions to include pH. In addition, the activity expands their experiences with mathematics scales, or representations, to include the pH scale. Just as they begin to understand temperature as the measure of the amount of heat in an area, they come to understand pH as a measure of where solutions fall between the extremes of high acidity and extremely basic.

Students create a pH scale and investigate the acidity of leaves while they are:

- recognizing that substances often are placed in categories or groups if they react in similar ways, such as an acid or base.
- making explanations and predictions from evidence and drawing logical conclusions.
- identifying variables that can affect the outcome of an experiment. In addition they will learn to identify other variables in an experimental design that must be controlled in order to isolate the affect of one variable.
- gaining skills and confidence in using a scientific measurement tool, pH probe, as well as the spreadsheet and graphing capacity of a computer to represent and analyze data.
- learning to value accuracy and precision in scientific investigation.

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Discussion Guide

Begin a discussion with the students by asking them to recall some of the environmental conditions that affected organisms in their aquatic and terrestrial environments. Challenge each group to discuss and then describe an environmental condition, its affect, and the evidence for the effect. The goal is to make the student aware of relationships. In addition, they should begin to develop skills for isolating variables. After about 10-15 minutes ask the groups to share their thinking.

One of the environmental variables students may mention is acidity. Introduce the idea that scientists try to be exact in their observations. As a result they develop mathematical scales to measure certain characteristics. Ask the class for examples of such scales. (They may mention temperature, decibels, hardness scales for rock, etc.) Propose they can make more careful observation about acidity of substances in their environment by using pH scale. Ask the students to report on their experiences with BTB or pH paper. Next, ask the students to think of two acids that they have experienced in their lives. Students may be aware that various citrus fruits or even tomatoes are acidic. Some students may also be aware of strong acids such as hydrochloric or sulfuric. Propose that BTB nor pH paper may not indicate the difference between these acids.

Show the class the pH probe and indicate that it uses a numeric scale to show much finer gradations of acidity than BTB or pH paper. Direct the students to "Thinking About the Question".

After the students have read the section and developed a procedure, check to make sure they have the idea that they must control as many variables as possible. They should also understand that they must begin by taking the pH of water before they add the lemon juice. Suggest to the class that they use the amount suggested in the activity so that they can compare results across groups.

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Additional Teacher Background

Students may be aware of acidity through previous investigations in which they tested aquatic environments with Bromothymol blue (BTB) or pH paper. They may have noticed, for example, that in the absence of plants or other animals, such as snails, leaving a goldfish in a container of water will eventually result in increased acidity. This is a result of fish exhaling carbon dioxide that combines with water to form carbonic acid. Increased nitrates in the water from waste products will also result in increased acid levels. They should also have observed that adding a plant, such as Elodea, to the water changes the acid level. Plants consume carbon dioxide in the presence of sunlight and will therefore reduce the carbonic acid in solution. At night, when the light is absent, both the plants and animals use up the excess oxygen and produce carbon dioxide. This creates more soluble carbonic acid at night, causing a decrease in pH. The stronger the acid, the lower the value on the pH scale.

Both pH paper and BTB are general indicators of acidity. The pH probe introduced in this activity permits observation of finer gradations in pH. In addition, because it can be connected to a computer, students can observe fluctuations in pH over time. Before students can use the pH probe in extended environmental inquiries, they need to develop as sense of the meaning of the pH scale. In the first part of the activity they experiment with a familiar acid, lemon juice and a familiar base baking soda. In the second part of the activity they build on this knowledge to investigate changes in acidity when different kinds of leaves are crushed in water.

While the best data is always obtained if teachers calibrate the probe, a default calibration is provided for the pH probe. If the teacher wishes to calibrate the probe, refer to your Vernier's pH probe instruction manual.

Neutral water has a pH of 7 and has equal amounts of hydrogen ion [H+] and hydroxide ions [OH-]. A solution that has more hydrogen ions than hydroxide ions is acidic. An acid has a pH less than 7. A solution that has more hydroxide ions than hydrogen ions is basic. A base has a pH greater than 7. The lower the pH, the stronger the acid and the higher the pH, the stronger the base.

For every one unit change of pH, there is a 10 fold change in acidity. That means a solution with a pH of 5 is 10 times more acidic than a solution with a pH of 6 and 100 times more acidic than a solution with a pH of 7.

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Changing pH Suggested Timeline

The amount of time you spend on introductory discussions, data collection, and analysis, will determine your overall timeline. The following represents a possible timeline.

- One class period - Introductory Discussion
- One class period - Investigation I: Testing the pH of lemon juice
- One class period - Investigation II: Testing the pH of a baking soda solution
- One class period - Investigation III: Testing the pH of different kinds of leaves
- One class period - Analysis

Additional days can be used for further investigations.

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