Agricultural Science
with Vernier

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Soil pH

When you think of pH, you probably think of liquid acids and bases. But soil can be acidic or basic, too. Soil pH, sometimes referred to as soil acidity, can be expressed using the *pH* scale. The pH scale ranges from 0 to 14. Soils with pH above 7 are basic or *sweet*. Soils with pH below 7 are acidic or *sour*. A soil with a pH of 7 is neither acidic nor basic, but is *neutral*.

Plant Nutrients	
Macronutrients	Micronutrients
Nitrogen	Iron
Phosphorus	Manganese
Potassium	Zinc
Sulfur	Copper
Calcium	Molybdenum
Magnesium	Cobalt
	Chlorine

The pH of soil is an important factor in determining which plants will grow because it controls which nutrients are available for the plants to use. Three primary plant nutrients – nitrogen, phosphorus, and potassium – are required for healthy plant growth. Because plants need them in large quantities, they are called *macronutrients*. They are the main ingredients of most fertilizers that farmers and gardeners add to their soil. Other nutrients such as iron and manganese are also needed by plants, but only in very small amounts. These nutrients are called *micronutrients*.

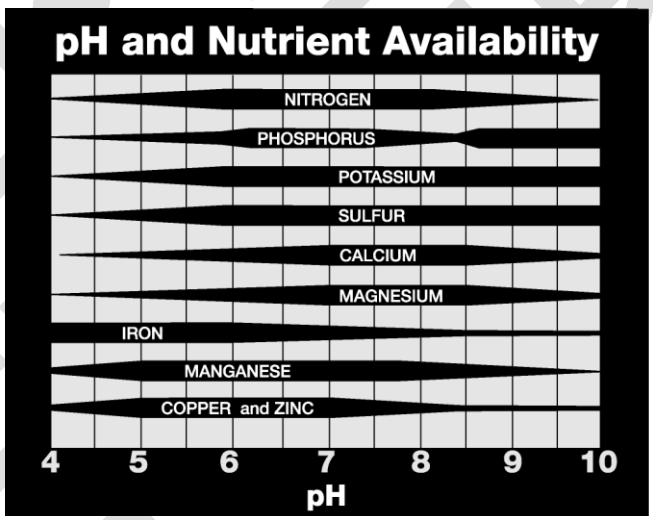

Figure 1

The availability of these nutrients depends not only on the amount but also on the form that is present, on the rate they are released from the soil, and on the pH of the soil. In general, macronutrients are more available in soil with high pH and micronutrients are more available in soil with low pH. Figure 1 shows the effect of pH on the availability of nutrients in the soil.

OBJECTIVES

In this experiment, you will

- Use a pH Sensor to measure the pH of soil samples.
- Identify any nutritional problems plants would have in that soil.

MATERIALS

- LabQuest
- LabQuest App
- Vernier pH Sensor
- 100 mL graduated cylinder
- two 250 mL beakers
- 2 soil samples
- distilled water
- waste cup
- wash bottle with distilled water
- 2 plastic spoons
- paper towels

PROCEDURE

1. Prepare the water-soil mixture.
   a. Label two beakers “A” and “B”.
   b. Place 50 g of Soil A into Beaker A. To avoid cross-contamination of the soils, leave this spoon in the beaker.
   c. Using a new spoon, place 50 g of Soil B into Beaker B. Leave the spoon in the beaker.
   d. Add 100 mL of distilled water to each beaker.
   e. Stir both mixtures thoroughly.
   f. Stir once every three minutes for 15 minutes.
   g. After the final stirring, let the mixtures settle for about five minutes. This allows the soil to settle out, leaving a layer of water on top for you to take your pH measurement. Continue with Steps 2–4 while you are waiting.

2. Connect the pH Sensor to LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor. **Important:** For this experiment your teacher already has the pH Sensor in pH soaking solution in a beaker; be careful not to tip over the beaker when connecting the sensor to the interface.

3. Set up the data-collection mode.
   a. On the Meter screen, tap Mode. Change the data-collection mode to Selected Events.
   b. Select Average over 10 seconds and select OK.

4. Calibrate the pH Sensor.

   If your instructor directs you to use the calibration stored in the experiment file, proceed to Step 5. If your instructor directs you to perform a new calibration for the pH Sensor, follow this procedure.

   a. Choose Calibrate from the Sensors menu.
   b. Select Calibrate Now.

   First Calibration Point

   c. Place the sensor tip into the pH 7 buffer.
   d. Enter **7** as the known pH value for Reading 1.
   e. When the voltage reading stabilizes, tap Keep.

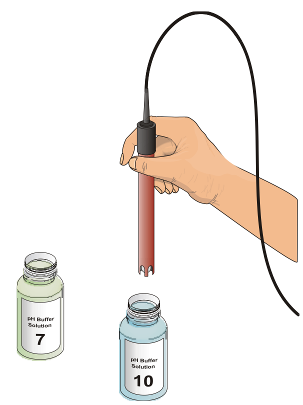

Figure 2

   Second Calibration Point

   f. Rinse the sensor with distilled water and place it in the pH 10 buffer solution.
   g. Enter **10** as the known pH value for Reading 2. When the voltage reading stabilizes, tap Keep. Select OK.

5. Measure the pH.
   a. Start data collection.
   b. Rinse the tip of the sensor with distilled water and place into the liquid part of Beaker A as shown in Figure 3.
   c. Tap Keep. **Important:** Leave the probe tip submerged while data is being collected for 10 seconds.
   d. Repeat data collection by again tapping Keep. Leave the probe tip submerged for the full 10 seconds.
   e. Stop data collection.
   f. Tap Table to view the data. Record the averaged pH values for readings 1 and 2.
6. Repeat Step 5 for the sample in Beaker B.
7. Rinse the pH Sensor with distilled water and return it to its storage container.
8. Your instructor will tell you whether you should keep the soil for further testing or clean up at this time.

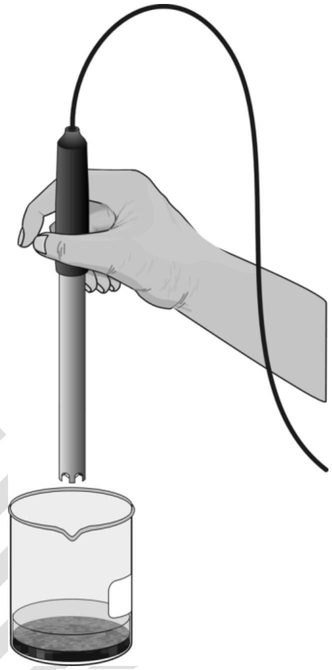

Figure 3

DATA

	Sample A	Sample B
Soil pH		

PROCESSING THE DATA

1. Are the soils acidic, basic, or neutral?
2. Plants growing in these soils might have trouble obtaining enough of some essential nutrients. According to Figure 1, which nutrients might be in short supply for each of the soils?

EXTENSIONS

1. Research the function of each nutrient and what symptoms the plant would have if they were not getting enough.
2. Test soil samples from your backyard or another environment and compare to your first results. Are the results the same or different? Try to explain why.
3. Research how farmers adjust the pH of soils. Design and conduct an experiment to test the effectiveness of their methods.

The Greenhouse Effect

Greenhouses allow gardeners to grow plants in cold weather. This is because the air inside the greenhouse stays warmer than the outside air. Short wavelength radiation from the sun passes through the glass, warming the interior of the greenhouse. The longer-wavelength radiation emitted does not pass through glass and is trapped in the greenhouse. This, along with the lack of mixing between the inside and outside air keeps the greenhouse consistently warm.

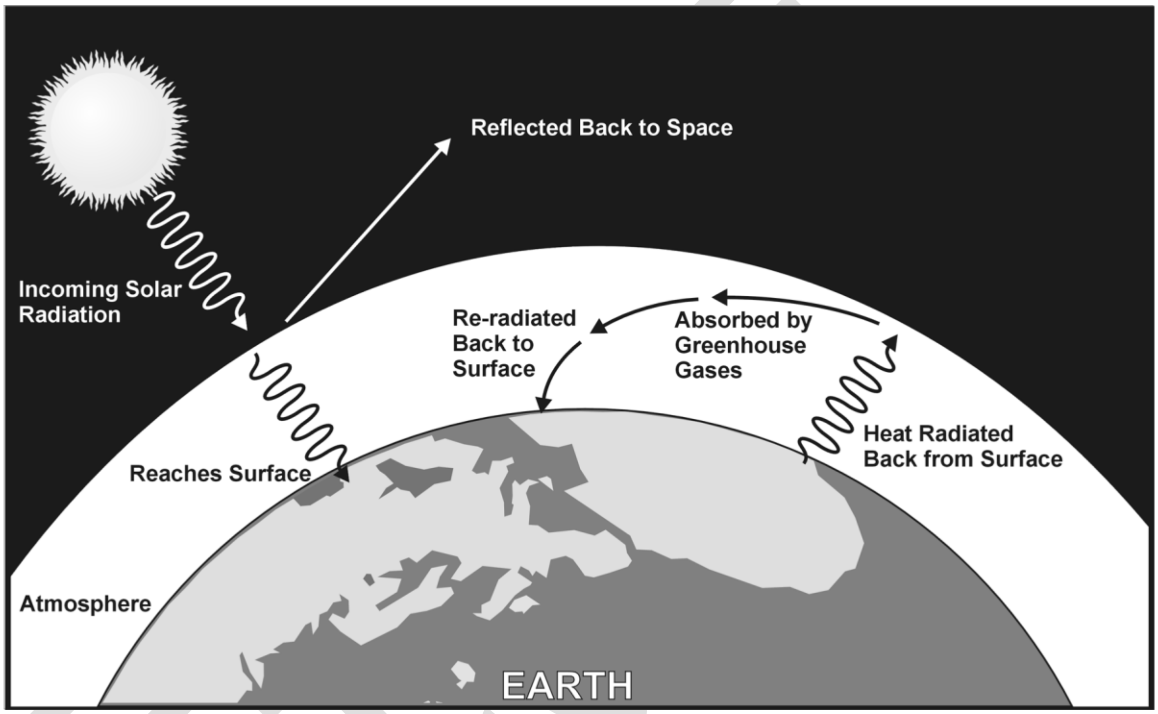

Figure 1

On a larger scale, the greenhouse effect helps keep our planet warm. Figure 1 shows how short wavelength radiation from the sun passes through the atmosphere, warming the Earth. The longer wavelength energy is then trapped by certain gases called greenhouse gases. The greenhouse gases most responsible are water vapor, carbon dioxide, methane, and nitrous oxide.

In this experiment, you will use two Temperature Probes to measure and compare the temperatures in model greenhouses under various conditions. In Part I, you will investigate the role of a plastic covering over the top of the model greenhouse. In Part II, you will investigate the effect of increased levels of two greenhouse gases – water vapor, H_2O, and carbon dioxide, CO_2.

OBJECTIVES

In this experiment, you will

- Use Temperature Probes to measure temperatures in a model greenhouse and a control.
- Use the results to make conclusions about the greenhouse effect.

MATERIALS

LabQuest	tape
LabQuest App	two 600 mL beakers
2 Temperature Probes	soil
lamp with 100 watt bulb	plastic wrap
2 rulers	a watch with a second hand

PROCEDURE

Part I The Effect of a Plastic Cover

1. Connect the two Temperature Probes to LabQuest and choose New from the File menu. If you have older sensors that do not auto-ID, manually set up the sensors.

2. Tape Temperature Probe 1 and Temperature Probe 2 each to a ruler as shown in Figure 2. The probe tips should each be 3 cm from the ruler ends and the tape should not cover the probe tips.

3. On the Meter screen, tap Rate. Change the data-collection rate to 10 samples/minute and the length to 15 minutes. Select OK.

4. Obtain two beakers and prepare them for data collection.
   a. Place a layer of soil 1 cm deep in each beaker.
   b. Place the Temperature Probes into the beakers as shown in Figure 2.
   c. Cover the top of Beaker 1 (the beaker containing Probe 1) tightly with plastic wrap. There should not be too much excess plastic wrap covering the sides of the beaker. Beaker 1 is your covered greenhouse and Beaker 2 remains uncovered and is the control.
   d. Position a lamp bulb the same distance from both beakers. The bulb should be about 5 cm above the tabletop and the same distance from the two probe tips.

Figure 2

5. Start data collection. Turn on the lamp and note the time on your watch.

6. Monitor the time. When 5 minutes have passed, turn off the lamp. Data will continue to be collected.

7. At the 10 minute mark, turn the lamp back on. Data collection will stop after 15 minutes.

8. When data collection stops, turn the lamp off and remove the Temperature Probes from the beakers.

9. Determine and record the temperature readings at the 5, 10, and 15 minute marks.
   a. When data collection is complete a graph of temperature *vs*. time will be displayed. To examine the data pairs on the displayed graph, tap any data point. As you tap each data point, the temperature values of both probes are displayed to the right of the graph.
   b. Tap the 0 minute data point.
   c. Record the Probe 1 (Greenhouse) and Probe 2 (Control) temperature values in the data table (to the nearest 0.1°C).
   d. Repeat Steps 9b–c to determine and record the Probe 1 and Probe 2 temperatures at the 5 minute, 10 minute and 15 minute marks.
10. Sketch or print copies of the graph as directed by your teacher.

Part II The Effect of Greenhouse Gases

11. Replace the ruler and probe. Cover Beaker 2 tightly with plastic wrap.
12. Lift the edge of the plastic wrap on Beaker 1 to make an opening.
13. Take a deep breath and hold it for as long as is comfortable. Without touching your lips to the beaker, exhale into the opening filling Beaker 1 with your breath.
14. Reseal the plastic over the top of the beaker and reposition near the lamp. **Important:** Make sure the beakers are the same distance from the lamp and are being illuminated evenly as in Part I.
15. Start data collection. Turn on the lamp and note the time on your watch.
16. Monitor the time using your watch. When 5 minutes have passed, turn off the lamp. Data will continue to be collected.
17. At the 10 minute mark, turn the lamp back on. Data collection will stop after 15 minutes.
18. When data collection stops, turn the lamp off.
19. Use the Step 9 procedure to determine and record the Probe 1 and Probe 2 temperatures at the 0 minute, 5 minute, 10 minute, and 15 minute marks.
20. Sketch or print copies of the graph as directed by your teacher.

DATA

Part I The Effect of a Plastic Cover

	Probe 1 Greenhouse	Probe 2 Control	Temperature Difference
0 Minute Temperature (°C)			
5 Minute Temperature (°C)			
10 Minute Temperature (°C)			
15 Minute Temperature (°C)			

Part II The Effect of Greenhouse Gases

	Probe 1 Greenhouse Gases	Probe 2 Control	Temperature Difference
0 Minute Temperature (°C)			
5 Minute Temperature (°C)			
10 Minute Temperature (°C)			
15 Minute Temperature (°C)			

PROCESSING THE DATA

Part I The Effect of a Plastic Cover

1. In the spaces provided in the data table, subtract to find the temperature differences.
2. During periods when the lamp was on, did the covered beaker warm faster or slower than the control?
3. Give a possible explanation for your answer to Question 2.
4. During periods when the lamp was off, did the covered beaker cool faster or slower than the control?
5. Give a possible explanation for your answer to Question 4.
6. Explain why a closed automobile heats up in the sun.

Part II The Effect of Greenhouse Gases

7. In the spaces provided in the data table, subtract to find the temperature differences.
8. What two important greenhouse gases did the exhaled air contain?

9. During periods when the lamp was on, did the beaker with greenhouse gases warm faster or slower than the control?
10. Give a possible explanation for your answer to Question 9.
11. During periods when the lamp was off, did the covered beaker warm faster or slower than the control?
12. Give a possible explanation for your answer to Question 11.
13. In what way is the greenhouse effect good for the Earth?
14. In what ways might the greenhouse effect become a problem for the Earth?

EXTENSIONS

1. Repeat the experiment using the sun as the light source.
2. Run the experiment for two hours. How are the results different than your results for the 15 minute data-collection period? Explain the differences.
3. Repeat the experiment using plastic containers instead of glass ones. Discuss any differences that result.