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Urgent Lessons: Measuring the Effects of Climate Change

Experiments:

Investigating Albedo

- Go Direct Light and Color Sensor
- Go Direct Surface Temperature Sensor

Acidification of Water by CO_2

- Go Direct pH

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Investigating Albedo

While radiation from the sun reaches every part of the Earth's surface, the heating caused by solar radiation is uneven due to a variety of factors, including the shape and tilt of the Earth as well as the texture and color of the surface.

The texture and color of the Earth surface affect the albedo, how much solar radiation is reflected, which also influences how much radiant energy, or heat, is absorbed in a particular location. A surface with a high albedo reflects a lot of solar radiation, while a surface with low albedo reflects very little. Since the Earth's surface is made of many colors and textures, it is heated unevenly. Snow, ice, and clouds reflect a lot of solar radiation back into space while green forests, vegetated lands, and exposed soil absorb solar radiation. You can experience the effect of albedo yourself with clothing on a sunny day. Would you feel cooler wearing a light- or dark-colored shirt on a hot, sunny day?

In this experiment, you will investigate the relationship between the albedo of different surfaces and the temperature change due to energy absorption. You will measure the amount of light reflected from paper of various colors using a light sensor and calculate percent reflectivity. You will also measure the temperature change of the air under the surface due to energy absorption using a temperature sensor.

OBJECTIVES

- Use a light sensor to measure the amount of light reflected from different colored pieces of paper.
- Calculate the albedo of different surfaces.
- Use a temperature sensor to measure the amount of energy absorbed for each color of paper.

MATERIALS

Chromebook, computer, **or** mobile device
Graphical Analysis app
Go Direct Light and Color Sensor
Go Direct Surface Temperature Sensor
ruler
lamp with 100 W equivalent bulb
white paper
black paper
foil
other colored paper (e.g., blue, orange, or purple)
tape

Figure 1

PROCEDURE

1. Prepare the sensors for data collection.
   a. Tape the Go Direct Surface Temperature Sensor to the table. Place the tape approximately 5 cm away from the tip as shown in Figure 1.
   b. Use a utility clamp and ring stand to fasten the Go Direct Light and Color Sensor 5 cm above the table top as shown in Figure 1. The sensors should be facing down toward the table.
   c. Position the lamp so that the bulb is 10 cm above the table top and next to the Light and Color Sensor.
2. Launch Graphical Analysis. Connect the Surface Temperature Sensor and the Light and Color Sensor to your Chromebook, computer, or mobile device.
3. Click or tap Mode to open Data Collection Settings. Change the Rate to 0.1 samples/second and End Collection to 600 seconds. Click or tap Done.
4. Place a sheet of smooth aluminum foil over the temperature sensor.

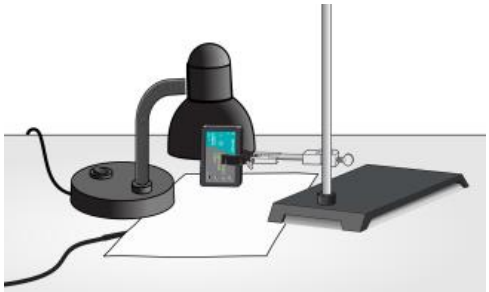

Figure 2

5. Switch on the lamp and start data collection.
6. When data collection is complete, turn off the lamp.
7. Determine and record the readings outlined below and record the values in your data table.
   a. Click or tap Graph Tools, ⊾, for the temperature graph and choose View Statistics.
   b. Record the starting and final temperature reading in your data table.
   c. Click or tap Graph Tools, ⊾, for the illumination graph and choose View Statistics.
   d. Record the mean reflection (illumination) reading.

8. Repeat Steps 4–7 for white and black paper. If time allows, make and record readings for two additional colors of paper.

DATA

Color	Aluminum	White	Black	_____	_____
Starting temperature (°C)					
Final temperature (°C)					
Change in temperature (°C)					
Reflection (lux)					
Albedo (%)	100				

PROCESSING THE DATA

1. Subtract to find the change in temperature for each color paper, and record the results in your data table.

2. Calculate the albedo for each type of paper using the foil as 100% albedo.

$$\text{albedo (\%)} = \frac{\text{reflection value for paper}}{\text{reflection value for aluminum}} \times 100$$

ANALYSIS QUESTIONS

1. Which color paper had the largest temperature increase?

2. Which color paper had the smallest temperature increase?

3. Which color paper has the highest albedo?

4. Which color paper has the lowest albedo?

5. What relationship do you see between albedo and temperature change? Explain how this can affect global temperatures.

6. What types of surfaces might give a planet a high albedo? Explain.

EXTENSIONS

1. Design an experiment to test the albedo of sand, soil, water, and other materials. Perform the experiment you designed.

2. Design an experiment to test the effect of texture on albedo. Perform the experiment you designed.

Acidification of Water by CO_2

As carbon dioxide gas, CO_2, dissolves in water, the following reaction occurs:

$$CO_2 + H_2O \leftrightarrow H_2CO_3$$

Carbonic acid, H_2CO_3, is a weak acid that as it increases in concentration, can lower the pH of natural bodies of water. As water becomes more acidic this results in damage to phytoplankton, zooplankton, coral, and any organism that has calcium carbonate as part of its body.

The acidity of a solution can be expressed using the pH scale, which ranges from 0 to 14. Solutions with a pH above 7 are basic, solutions with pH below 7 are acidic, and a neutral solution has a pH of 7. In this experiment, you will study how the pH of water changes when CO_2 is dissolved in water.

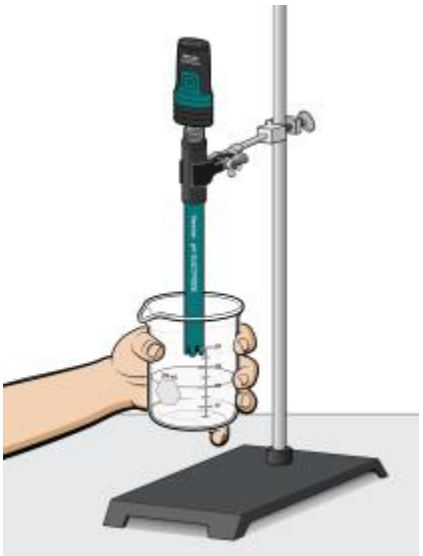

Figure 1

OBJECTIVES

- Use a pH Sensor to measure changes in pH.
- Study the effect of dissolved CO_2 on the pH of water.
- Learn why some bodies of water are more vulnerable to acidification than others.

MATERIALS

Chromebook, computer, **or** mobile device
Graphical Analysis 4 app
Go Direct pH
250 mL beaker
100 mL beaker (rinse beaker)
125 mL Erlenmeyer flask
10 mL graduated cylinder
stopper with tubing
buffer solution
2 Alka-Seltzer tablets
water
ring stand
utility clamp
wash bottle with distilled water
waste container
water samples from natural bodies of water (lake, stream, ocean)
goggles

PROCEDURE

1. Obtain and wear goggles.
2. Before each use of the pH Sensor, you need to rinse the tip of the sensor thoroughly with distilled water. To do this, hold the pH Sensor above a rinse beaker and use the wash bottle to thoroughly rinse the sensor tip. **Important**: Do not let the pH Sensor dry out. Keep it in a 250 mL beaker with about 100 mL of tap water when not in use. The tip of the sensor is made of glass—it is fragile. Handle with care!
3. Launch Graphical Analysis. Connect the pH Sensor to your Chromebook, computer, or mobile device.
4. Place one Alka-Seltzer tablet in the Erlenmeyer flask.
5. Put 100 mL of fresh water into a clean 250 mL beaker.
6. Using a ring-stand and utility clamp, secure the pH Sensor in the beaker. The tip of the sensor should be down in the water sample. Swirl the water around the sensor tip briefly. **Note**: All glassware must be clean in this experiment!
7. Once the pH reading stabilizes, click or tap Collect to start data collection.
8. Quickly place 10 mL of water in the Erlenmeyer flask then seal with the stopper. Place the tubing in the water sample so it starts to bubble the water with the gas being released from the reaction.
9. When data collection is finished, click or tap on Graph Tools, , and choose Statistics to determine the maximum and minimum pH values. Record the maximum and minimum pH in Table 1.
10. Repeat Steps 4–9 using a different water sample form a natural source in place of fresh water. **Note**: The previous data set is automatically saved.

11. Tap on the y-axis and select all data sets to view all four on the same plot. Use this graph to answer the discussion questions at the end of this experiment.

DATA

Water Type	Maximum pH	Minimum pH	ΔpH

QUESTIONS

1. Calculate the change in pH (ΔpH) for each water sample. Subtract the final pH from the initial pH. What conclusion can you make about your breath?

2. Why does the pH change rapidly at first, and remain stable after a time?

3. Compare the ΔpH values. Which test gave the largest pH change? Which test gave the smallest pH change?

4. Water from the ocean is said to be "naturally buffered." From the result of this experiment, what does this mean?

5. How does water from the ocean become buffered?

6. Many aquatic life forms can only survive in water with a narrow range of pH values. In which body of water—lakes or oceans—would living things be more threatened by acidification? Explain.

7. Summarize your conclusions about this laboratory experiment. Use your data to answer the purposes of this experiment.

EXTENSIONS

1. Test hard and soft water in the same way you tested lake and ocean water. How do they compare?

2. Do research to get more information on the effects of acidification on ocean and freshwater.

3. Do research and prepare a report on "naturally buffered" streams and lakes.