You recently obtained a job working for an environmental consulting firm, the Environmental Brain Trust. Your firm, famous for “brainstorming,” has recently received an anxious plea for help from Oscar Frizbee, owner of Oscar’s Onions. The distraught Oscar described how his onions failed to take root. He had tried everything, including the latest watering system and the finest organic fertilizer. Oscar suspected that runoff from a nearby bleach company had contaminated groundwater underneath his farm. Oscar has done the first step for you: he has observed that his onions have failed to take root. It’s up to you and your coworkers to develop a hypothesis to explain the mystery of the failed crop.

OBJECTIVES

Identify the problem.
Create a hypothesis that you can test to find out the reason behind the problem.
Gather data by experimenting.
Analyze and contrast your data to identify differences.

MATERIALS

- beaker
- bleach
- graduated cylinder
- graph paper
- knife
- notebook
- organic fertilizer (bone meal or fish meal)
- pen or pencil
- ruler, metric
- stirring rod
- test-tube rack
- test tubes, large
- water, distilled
- wax pencil
- white onion bulbs between 1.5 and 2.0 cm in diameter (unsprouted, mold-free, and of approximately the same size)

Procedure

PART I—MAKE A HYPOTHESIS

1. Get together with your team, and discuss the mystery of the failed crop. Decide what scientific problem you need to solve, and write the problem below.
2. First list all the variables that might have affected Oscar's onions, based on his description. Working with your team, pick one variable that you think is a likely cause of the problem, and develop a hypothesis. Write your hypothesis below. Remember: a hypothesis is a prediction of what the correct answer might be, based on prior knowledge and experience.

3. Share your team’s hypothesis with the class. Your teacher will write the hypothesis on the board. There should be several hypotheses for each variable.

PART II—DESIGN THE EXPERIMENT

4. The next step is to test your hypothesis. You will investigate the growth of onions by growing bulbs in test tubes filled with different growing solutions. The components of the solutions depend on which variable your team is testing. With your team, decide on the amounts (concentrations) of the substances in your test solutions. Here are some other questions you need to answer before you begin:
   a. What will your sample size be?

   b. Is it necessary to set up a control? Why or why not?

5. Write the procedure for your team’s experiment on a separate sheet of paper. Create a data collection chart to record your data. Design your chart according to the conditions of this experiment as defined in your procedure.

PART III—PERFORM THE EXPERIMENT AND COLLECT DATA

6. Fill the test tubes with the solutions that you are testing. Label each test tube, and set the test tubes in a rack. Remove the onions’ outer layers, and cut off a 2 mm slice from the bottom of each onion. Insert the onion bulbs into the test tubes so that the bottom of the bulb is immersed in the solution. Set the test-tube rack in a sunny location.
7. Over a five-day period, take note each day of the root growth of the onions. Measure the growth using a metric ruler, and record your data in the chart you created.

Analysis

1. Constructing Graphs After you have collected all your data, make a line graph comparing root growth over time in the solutions you tested. Explain why a line graph is a good way to represent your data.

2. Analyzing Results Did your results support your hypothesis? Explain.

3. Recognizing Patterns Compare your team’s chart with those of your classmates. Which hypotheses were supported?
Conclusions

4. Evaluating Methods  In your experiment, what variable did you change, and what variables did you hold constant? Why is it important to make sure that only one variable is changed for your test?

5. Interpreting Information  What conclusions can you draw from the class results?

6. Making Predictions  Describe an experiment you could do to test the effect of another variable on onion growth.

7. Interpreting Information  Write a report that includes your hypothesis, data, and analysis to send to your client.

Extension

1. Research and Communications  In a cranberry bog, the water and soil pH numbers should be in the 4.5 to 5.0 range for good cranberry production. Use your school library or the Internet to research the variables faced by a cranberry grower. For example, what variables do cranberry growers face when they treat the soil the cranberries grow in? How do the growers solve these problems?
Teacher Notes

TIME REQUIRED  Two 45-minute periods

SKILLS ACQUIRED
  Collecting data
  Communicating
  Identifying and recognizing patterns
  Experimenting

RATING
  Teacher Prep–2
  Student Set-Up–2
  Concept Level–2
  Clean Up–2

THE SCIENTIFIC METHOD

Ask Questions  Procedure, step 1
Test the Hypothesis  Procedure, steps 4–6
Analyzing Results  Analysis, questions 2 and 3
Draw Conclusions  Conclusions, questions 4–7
Communicate the Results  Conclusions, question 4

MATERIALS

Materials listed are enough for groups of five students.

SAFETY CAUTIONS

Check for any known student allergies to organic fertilizers or bleach. Some fertilizers can be absorbed through the skin. Dilute and dispense the bleach yourself, and be sure students handle the materials carefully. When handling the bleach, students should work in a well-ventilated area so they do not inhale the fumes. Remind students to wear protective eyewear, gloves, and a lab apron when handling the fertilizer and bleach so they do not get it on their hands, clothing, or other surfaces.

MISCONCEPTION ALERT

Students may not understand the role that roots play in the health of a plant. Explain why plants need roots.

TIPS AND TRICKS

Define control and variable. Point out to students that a control and two or more variables are essential in understanding results. Make sure that students test only one variable.
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**OBJECTIVES**

**Identify** the problem.

**Create** a hypothesis that you can test to find out the reason behind the problem.

**Gather** data by experimenting.

**Analyze** and contrast your data to identify differences.

**MATERIALS**

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- stirring rod
- test-tube rack
- test tubes, large
- water, distilled
- wax pencil
- white onion bulbs between 1.5 and 2.0 cm in diameter (unsprouted, mold-free, and of approximately the same size)

**Procedure**

**PART I—MAKE A HYPOTHESIS**

1. Get together with your team, and discuss the mystery of the failed crop. Decide what scientific problem you need to solve, and write the problem below.

   **The scientific problem is:** Why did Oscar’s onions not take root?
2. First list all the variables that might have affected Oscar’s onions, based on his description. Working with your team, pick one variable that you think is a likely cause of the problem, and develop a hypothesis. Write your hypothesis below. Remember: a hypothesis is a prediction of what the correct answer might be, based on prior knowledge and experience.

**Possible variables include the amount of water, the amount of organic fertilizer, and the amount of bleach in the groundwater underneath the farm.**

**Sample hypothesis:** The onions failed to take root because the new watering system did not provide them with adequate moisture.

3. Share your team’s hypothesis with the class. Your teacher will write the hypothesis on the board. There should be several hypotheses for each variable.

**PART II—DESIGN THE EXPERIMENT**

4. The next step is to test your hypothesis. You will investigate the growth of onions by growing bulbs in test tubes filled with different growing solutions. The components of the solutions depend on which variable your team is testing. With your team, decide on the amounts (concentrations) of the substances in your test solutions. Here are some other questions you need to answer before you begin:

- **a.** What will your sample size be?

**Sample size may vary but should consist of at least three onions for each experimental condition.**

- **b.** Is it necessary to set up a control? Why or why not?

**A control is necessary because it provides a standard against which change can be measured.**

5. Write the procedure for your team’s experiment on a separate sheet of paper. Create a data collection chart to record your data. Design your chart according to the conditions of this experiment as defined in your procedure. **Procedure and charts will vary depending on the chosen variable and experimental conditions.**

**PART III—PERFORM THE EXPERIMENT AND COLLECT DATA**

6. Fill the test tubes with the solutions that you are testing. Label each test tube, and set the test tubes in a rack. Remove the onions’ outer layers, and cut off a 2 mm slice from the bottom of each onion. Insert the onion bulbs into the test tubes so that the bottom of the bulb is immersed in the solution. Set the test-tube rack in a sunny location.
7. Over a five-day period, take note each day of the root growth of the onions. Measure the growth using a metric ruler, and record your data in the chart you created.

Analysis

1. Constructing Graphs After you have collected all your data, make a line graph comparing root growth over time in the solutions you tested. Explain why a line graph is a good way to represent your data.

   Line graphs are a good way to represent data that changes over time.

2. Analyzing Results Did your results support your hypothesis? Explain.

   Answers may vary.

3. Recognizing Patterns Compare your team’s chart with those of your classmates. Which hypotheses were supported?

   Answers may vary.
Conclusions

4. Evaluating Methods In your experiment, what variable did you change, and what variables did you hold constant? Why is it important to make sure that only one variable is changed for your test?

Answers may vary. Sample answer: The amount of water is the variable that was changed. All variables except the water remained constant. Changing only one variable is necessary to identify clearly the factor that is inhibiting the growth of the roots.

5. Interpreting Information What conclusions can you draw from the class results?

Answers may vary.

6. Making Predictions Describe an experiment you could do to test the effect of another variable on onion growth.

Answers may vary. Sample answer: To test the effects of acid rain or salt accumulation on the onion bulbs, students could use the procedure outlined in this investigation and incorporate solutions of varying levels of acidity or salinity.

7. Interpreting Information Write a report that includes your hypothesis, data, and analysis to send to your client.

Extension

1. Research and Communications In a cranberry bog, the water and soil pH numbers should be in the 4.5 to 5.0 range for good cranberry production. Use your school library or the Internet to research the variables faced by a cranberry grower. For example, what variables do cranberry growers face when they treat the soil the cranberries grow in? How do the growers solve these problems?