1. Acid Rain and Seed Germination

How you Bean?

Driving Question

How does acid in rain affect the growth of seeds?

Materials and Equipment

For each student or group:

- ☐ Data collection system
- ☐ pH sensor
- ☐ Bean seeds (15)
- ☐ Distilled water, 100 mL
- ☐ Permanent waterproof marker
- ☐ Simulated acid rain samples (2), 100 mL
- ☐ Plastic cups, 250 mL (3)
- ☐ Resealable small plastic bags (3)
- ☐ Stirring rod or plastic spoon
- ☐ Ruler
- ☐ Paper towels

Safety

Add this important safety precaution to your normal laboratory procedures:

- ■ Wear safety glasses and lab coats or aprons.

Thinking about the Question

Chalk is composed of calcium carbonate. Chalk is similar to a rock called limestone. Limestone is used in the construction of buildings, statues and monuments. Acid rain affects some stone and metal buildings and statues the same way that vinegar affects chalk.

How do you think that varying strengths of acid will affect pieces of chalk?

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When factories burn coal or oil, many gases are given off, including sulfur dioxide. In the atmosphere, sulfur dioxide can react with water vapor to form sulfuric acid. Car exhaust contains nitrogen oxides, which can react in the atmosphere to form nitric acid. The acids are carried back to Earth with precipitation and they can even fall to the ground on dry days as dust-like particles. Acid rain can kill plants and fish, damage buildings and roads, and contaminate public water supplies.

In this activity, you will investigate the effect of simulated "acid rain" on the germination of seeds.

Sequencing Challenge

☐ **The steps below are part of the Procedure for this lab activity. They are not in the right order. Determine the proper order and write numbers in the circles that put the steps in the correct sequence.**

Test and record the pH of each of the water samples.	Obtain and label samples of acid rain water and distilled water.	Moisten a paper towel with water from the sample; arrange 5 bean seeds in the towel so they will germinate.	Measure and average the length of the growing roots of the bean seeds over several days' time.	Make sure that each member of your lab group is aware of the safety rules and procedures for this lab.

Investigating the Question

☐ **Note:** When you see the symbol "**❖**" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step. Your teacher will provide you with a copy of the instructions for these operations.

Part 1 – Making predictions

1. ☐ Your teacher has prepared some samples that simulate acid rain water. How do you think the pH of these samples will differ from the pH of distilled water? Record your prediction about the pH of the samples.

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2. ☐ Predict how watering bean seeds with acid rain will affect the growth these seeds.

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Part 2 – Testing the pH of the water

3. ☐ Collect the prepared acid rain water samples and distilled water in small plastic cups. Identify each sample of water according to its origin as follows: Label the cups "A", "B", and "C". Fill cups A, and B with 100 mL of each acid rain sample; fill cup C with 100 mL of distilled water.

4. ☐ Start a new experiment on the data collection system. ◆(1.2)

5. ☐ Connect a pH sensor to the data collection system using a sensor extension cable. ◆(2.1)

6. ☐ Display pH in a digits display. ◆(7.3.1)

7. ☐ Rinse the pH sensor with distilled water.

8. ☐ Why is the sensor rinsed with distilled water before testing each sample?

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9. ☐ Monitor live data without recording. ◆(6.1)

10. ☐ Place the sensor into the first cup, and gently stir the solution with the sensor during data collection.

11. ☐ Wait until the pH reading stabilizes (up to 60 seconds).

12. ☐ Record the pH in Table 1 in the Answering the Question section below.

13. ☐ Remove the pH sensor from the cup.

14. ☐ Rinse the probe with distilled water, monitor and record a stabilized pH for the other two water samples, as you did for the first sample.

15. ☐ Stop data monitoring. ◆(6.1)

Part 3 – Observing acid rain's effect on seed germination

16. ☐ Use a waterproof marker to label where seeds one through five will go on a paper towel.

    ☐ **Note:** This will help with measuring the length of the roots later.

17. ☐ Slightly wet this paper towel with distilled water. Place 5 seeds near the numbers and fold the towel over the seeds several times so that it will fit into the small plastic bag.

18. ☐ Why should the towel just be damp and not sopping wet?

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19. ☐ Place the towel inside a re-sealable bag and label it with a permanent marker as "Control." The bag should be left open to the air.

20. ☐ On another paper towel, use a permanent marker to label where seeds 1 to 5 will go. Slightly wet this paper towel with water from the acid rain water sample from cup A. Place 5 seeds near the numbers and fold the towel over the seeds several times so that it will fit into the small plastic bag. Make sure the towel is just damp.

21. ☐ Place the towel inside a re-sealable bag and label it with a permanent marker as "Acid Rain Sample A." The bag should be left open to the air.

22. ☐ Repeat this procedure for acid rain water sample B.

23. ☐ Place all of the bags in an indoor location where they will get sunlight through a window for at least 2 hours each day.

24. ☐ Measure the root length of each bean in each bag after 3 or 4 days. Average the root length for each bag. Record this data in Table 2 in the Answering the Question section below.

25. ☐ Measure the root length of each bean in each bag each day for the next 2 to 3 days.

Answering the Question

Analysis

Table 1: pH levels of distilled water and acid rain water samples

Sample	pH
Control	
Acid Rain Water Sample A	
Acid Rain Water Sample B	

Table 2: Bean seed root length

Sample	Average Root Length Day 1 (mm)	Average Root Length, Day 2 (mm)	Average Root Length, Day 3 (mm)	Average Root Length, Day 4 (mm)
Control				
Acid Rain Sample A				
Acid Rain Sample B				

1. Look at the data in Table 1 above. What was the range of pH in your water samples (recall that the range of a set of data is the difference between the highest and lowest value)?

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2. Analyze your data from Table 2 above. How did the growth of the roots vary between the samples?

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3. How did your predictions compare to the actual growth of the roots?

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4. Based on the evidence from your investigation, does acidic rain water promote the healthy growth and thriving of young plants? Explain your thinking.

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5. Why is it considered good experimental design to average the growth of 5 seeds for one sample of water, rather than germinating one seed per sample of water?

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6. Imagine that you are a farmer planting a crop of beans to grow, harvest, and sell. As a farmer, you contribute to the nation's food supply and earn a living. Two days after you plant the crop, it rains, watering the new seeds in the process. You test the rain water and are alarmed at how low its pH is — your new crop has just been soaked with acid rain! Discuss some of the implications of this event, and write your thoughts in the space below.

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