

**Investigative Lab 2**

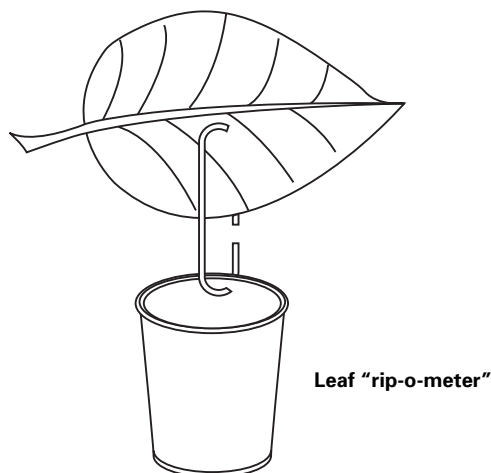
## Making a Rip-o-meter

### *Design an Experiment to Measure Leaf Toughness*

**Inquiry Challenge** How can you use measurements of leaf toughness to test a hypothesis? What factors may contribute to leaf toughness?

**Lab Overview** In this inquiry investigation you will make a “rip-o-meter”—a simple device used to measure leaf toughness. You will consider how to use leaf toughness measurements to test one or more hypotheses, then design and carry out an experiment of your own.

**Introduction** Making a leaf rip-o-meter like the one shown below provides a simple way to quantitatively measure the “toughness” of a leaf. First you will hang a paper cup from a leaf by a paper clip. Then you will add pennies to the cup until the paper clip rips through the leaf. The number of pennies required to rip completely through the leaf is a measurement of leaf toughness. To start your investigation, you will study an example of an experiment that one student designed and carried out using a leaf rip-o-meter. You will analyze the results of this student’s experiment and answer questions based on the data. Then you’ll design your own experiment using a rip-o-meter.



**Background** A leaf’s toughness depends on certain substances in its cells. Plant cells are surrounded by cell walls made of a fibrous material called cellulose. Some plant cell walls also contain a tougher fiber called lignin. Cellulose and lignin add strength and rigidity to leaves and other plant structures, helping plants stand upright and withstand the forces of wind and rain. Leaves of some plants have much tougher cell walls than others. For example, the leaves of palm trees are much tougher than the leaves of lettuce plants.

To design an experiment that gives meaningful results, it is important to make sure that the experiment tests only one variable at a

time. For your rip-o-meter experiment, this means that the two types of leaves you choose to test should vary in only one way. If you test leaves that vary in several ways, such as leaves from different plants that have been exposed to different amounts of sun and wind and grown in different soils, you will not be able to conclude which variable is connected to any measured differences in leaf toughness. In your experiment you will test leaves from a single type of plant. In the experiment you will read about in the Prelab Activity below, notice how the student designed the experiment to control as many variables as possible.

**Prelab Activity** Study the description below of one student’s leaf rip-o-meter experiment. Consider the experimental design and the results. Then, answer the Prelab Questions.

**Sample Experiment**

**Observation:** Leaves that grow on the same jasmine plant are exposed to different amounts of sun.

**Question:** Are jasmine leaves that are exposed to the sun for most of the daytime tougher than leaves of the same plant that are in constant shade?

**Hypothesis:** Jasmine leaves exposed to sun for most of the daytime are tougher because they need to withstand the heat.

**Prediction:** If jasmine leaves exposed mostly to sun are tougher, then leaves exposed mostly to shade will tear more easily.

**Experiment:** I will gather one batch of sun-exposed leaves and one batch of shade-exposed leaves, then test them with the rip-o-meter.

**To control variables:** I will collect leaves that are the sixth one inward from the tip of a branch, to make sure that all the leaves will be about the same age. I will test five leaves of each type, calculate the average toughness of each batch, and then compare the results.

I will pierce each leaf with the rip-o-meter paper clip just below the middle vein of the leaf. I will add pennies to the cup until the leaf rips completely through.

**Rip-o-meter Test Data**

Sun-Exposed Leaf	Pennies Added	Shade-Exposed Leaf	Pennies Added
1	89	1	73
2	70	2	94
3	77	3	88
4	80	4	83
5	89	5	72
Average for sun	81	Average for shade	82

### Prelab Questions

1. Which variable is the student's experiment described in the Prelab Activity designed to test?

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2. List three other possible variables in this experiment and explain what the student did to control each one.

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3. Which of the following conclusions is best supported by the data the student collected? Explain.

- a. Jasmine leaves exposed mostly to shade are tougher than those grown in the sun.
- b. Jasmine leaves exposed mostly to sun are tougher than those grown in the shade.
- c. The amount of sun exposure does not seem to affect the toughness of jasmine leaves.

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4. If the student had tested only one leaf grown in the sun and one leaf grown mostly in the shade, might that data have supported a different conclusion? Explain.

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### Materials

- paper cup
- paper clip
- approximately 150 pennies
- 2 plastic sandwich bags
- masking tape
- marker
- leaves

## Procedure



### Part A: Developing Your Hypothesis

1. Your teacher will discuss with you the sources of leaves you will use for this lab. Based on this information, observe the possible leaves and brainstorm questions you could explore with the leaf rip-o-meter. Choose one and write it in the space below.

**Question:**

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2. Form a testable hypothesis and record it below. (Hint: Write your hypothesis in the form of a statement.)

**Hypothesis:**

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3. Predict what will happen when you test your hypothesis. Write your predictions in the space below, and explain them.

**Predictions:**

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### Part B: Designing Your Experiment

1. Devise an experiment to test your hypothesis, and describe it below. Describe the two groups of leaves you will collect and test. Remember that the best experiments test only one variable. List possible variables and explain how you plan to control each one. (Attach another piece of paper if necessary.)

2. List the steps of the procedure for your planned experiment.

**Proposed Procedure:**

3. Have your teacher approve your procedure before you start. If you need to revise your procedure, write the new procedure below.

**Revised Procedure:**

**Part C: Collecting and Testing Leaves**

1. Follow your teacher's instructions about collecting leaves. Collect two batches of leaves. Place each batch in a separate plastic sandwich bag. Use masking tape and a marker to label each bag with the date, your group's name, and a description of the leaf type. If you collect the leaves the day before the lab, place a moist paper towel in the bag so that the leaves do not wilt.
2. After collecting your leaves, observe them closely. Note any differences between the batches. For example, you may observe differences in leaf size, shape, color, or thickness.
3. Build your rip-o-meter, following the description and illustration in the Introduction.
4. Test the leaves with the rip-o-meter. Record your results in Data Table 1 on the next page.

**Data Table 1**

Batch 1 Leaves	Pennies Added	Batch 2 Leaves	Pennies Added
Average Batch 1		Average Batch 2	

**Analysis and Conclusions**

1. What variable did you test in your experiment?

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2. How did you control other variables in your experiment?

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3. Based on your data, do you think that the variable you tested had any effect on leaf toughness? Why or why not?

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4. Based on the results of your experiment, could you now say your hypothesis is a theory? Why or why not?

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**Extension**

Design a second experiment that uses the leaf rip-o-meter to test a different variable. Carry out the second experiment. Then compare your data with the results of your first experiment. (**NOTE:** *Always obtain permission from your teacher before carrying out any experiments.*)