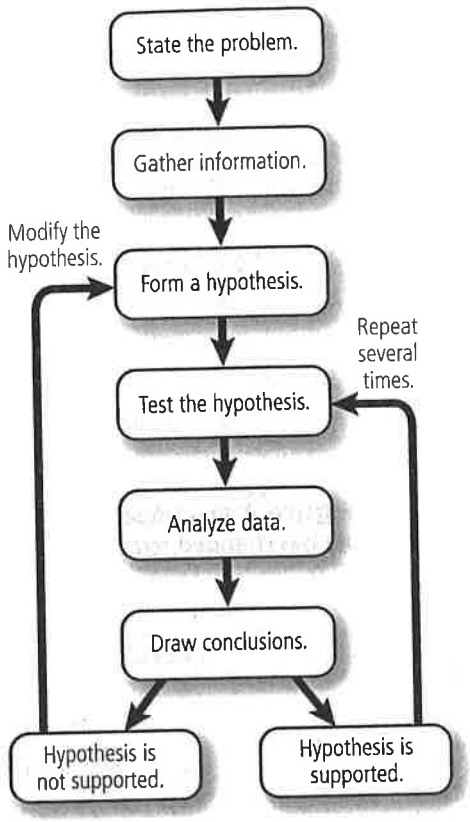
Name _____



■ **Figure 3** The series of procedures shown here is one way to use scientific methods to solve a problem.

Concepts in Motion **Interactive Concept Map**

Video **BrainPOP**

Scientific Methods

Although scientists do not always follow a rigid set of steps, investigations often follow a general pattern. The pattern of investigation procedures is called the **scientific methods.** Six common steps found in the scientific methods are shown in **Figure 3.** A scientist might add new steps, repeat some steps many times, or skip steps altogether.

State the problem To begin the process, a scientist must state what he or she is going to investigate. Many investigations begin when someone observes an event in nature and wonders why or how it occurs. The question of "why" or "how" is the problem.

Scientists once posed questions about why objects fall to Earth, what causes day and night, and how to generate electricity for daily use. Many times a statement of a problem arises when an investigation is complete and its results lead to new questions. For example, once scientists understood why we experience day and night, they wanted to know why Earth rotates.

Sometimes a new question is posed when an investigation runs into trouble. For example, some early work on guided missiles found the instruments in the nose cone did not always work properly. The original problem statement involved finding materials to protect the instruments during flight. The new statement involved how to repair the instruments.

Research and gather information

Before beginning an investigation, scientists research what is already known about the problem. They gather and examine observations and interpretations from reliable sources. This background helps the scientist fine-tune his or her question and form a hypothesis.

Form a hypothesis A **hypothesis** is a possible explanation for a problem using what you know and what you observe. When trying to find a better material to protect the space shuttle, NASA scientists looked to other materials that were used in similar situations. Scientists knew that a ceramic coating had been found to solve the guided missile problem. They hypothesized that a ceramic material might work on the space shuttle.

Test a hypothesis Some hypotheses can be tested by making observations. Others can be tested by building a model and relating it to real-life situations. One common way to test a hypothesis is to perform an experiment. An **experiment** tests the effect of one thing on another using a control.

Variables An experiment usually contains at least two variables. A **variable** is a quantity that can have more than a single value. **Table 1** summarizes the types of variables. For example, as shown in **Figure 4,** numerous experiments aboard space shuttles and the *International Space Station* have studied the effects of microgravity on plants. Before these experiments could begin, scientists had to think of every factor that might affect plant growth. Each of these factors is a variable.

Independent and dependent variables In the microgravity experiment, plant growth is the **dependent variable** because its value changes according to the changes in the other variables. The variable changed to see how it will affect the dependent variable is called the **independent variable.** The microgravity is the independent variable.

Constants To be sure they were testing to see how microgravity affects growth, mission specialists kept the other possible factors the same. A factor that does not change is called a **constant.** The microgravity experiments used the same soil and type of plant. Additionally, each plant was given the same amount of light and water and was kept at the same temperature. Type of soil, type of plant, amount of light, amount of water, and temperature were constants for this experiment.

Table 1 Types of Variables

Dependent Variable	changes according to the changes of the independent variable
Independent Variable	the variable that is changed to test the effect on the dependent variable
Constant	a factor that does not change when other variables change
Control	the standard by which the test results can be compared

Figure 4 An astronaut displays soybean plants growing in a microgravity experiment aboard the *International Space Station.* One goal of this experiment was to find out whether soybean plants would produce seeds in a microgravity environment.

Controls A **control** is the standard by which the test results can be compared. After the mission specialists gathered their data on the plants grown in microgravity, they could compare their results with the same types of plants grown on Earth's surface with the same constants. This comparison allowed them to analyze the data and form a conclusion about whether microgravity has an effect on plant growth.

Reading Check Identify What is the purpose of a control in an experiment?

VOCABULARY

ACADEMIC

Infer

coming to a logical conclusion based on observations and evidence

After observing a trail of ants in his kitchen, Joe inferred there was some sugar spilled somewhere.

Analyze the data

An important part of every investigation includes recording observations and organizing the test data into easy-to-read tables and graphs. Later in this chapter, you will study ways to display data. When you are making and recording observations, you should include all results, even unexpected ones. Many important discoveries have been made from unexpected results.

Scientific inferences are based on observations made using scientific methods. All possible scientific explanations must be considered. If the data are not organized in a logical manner, wrong conclusions can be drawn. When a scientist communicates and shares data, other scientists will examine that data, how it is analyzed, and compare it to the work of others. Scientists share their data through reports and conferences. In **Figure 5,** a student is presenting his data.

Draw conclusions

Based on the analysis of the data, the next step is to decide whether the hypothesis is supported. For the hypothesis to be considered valid and widely accepted, the experiment must result in the exact same data every time it is repeated. If the experiment does not support the hypothesis, the hypothesis must be reconsidered. Perhaps the hypothesis needs to be revised, or maybe the experiment's procedure needs to be refined.

? Inquiry **Virtual Lab**

Figure 5 An exciting and important part of investigating something is sharing your ideas with others, as this student is doing at a science fair.