# Objective 1

**The student will demonstrate an understanding of the nature of science.**

## From your studies in science, you should be able to show an understanding of the nature of science.

**The nature of science? What's that? Isn't nature just the outdoors?**

When people talk about nature, they often do mean the outdoors. But that's not what we mean when we talk about the nature of science. The nature of science has to do with what science is and how scientists learn about the world.

**So what exactly is science?**

Science includes all that we know about the natural world and the universe. The information in your science textbook is part of science. Asking a question about the natural world and making a plan to find the answer is science too. So science isn't just something you know. It's also something you do.

**Well, that's great to know. But I'm not a scientist. I'm just a kid. Why do I need to understand science?**

Anyone can study the world around us. I'll bet you're a scientist and you don't even know it! Go ahead. Ask a question about something you would really like to know.

**Is it going to rain during my soccer game tomorrow? How's that for a science question?**

Very good! How will you find out whether it might rain tomorrow?

**I'll listen to the weather report on the radio. Then I'll look out the window in the morning and see whether it's cloudy.**

Who says you're not a scientist? You asked a question, and you made a plan to find the answer to your question. Ordinary people like you and me do science every day. Even scientists who make great discoveries start out by doing just what you did. They wonder about something and ask a question. Then they come up with a plan for finding the answer.

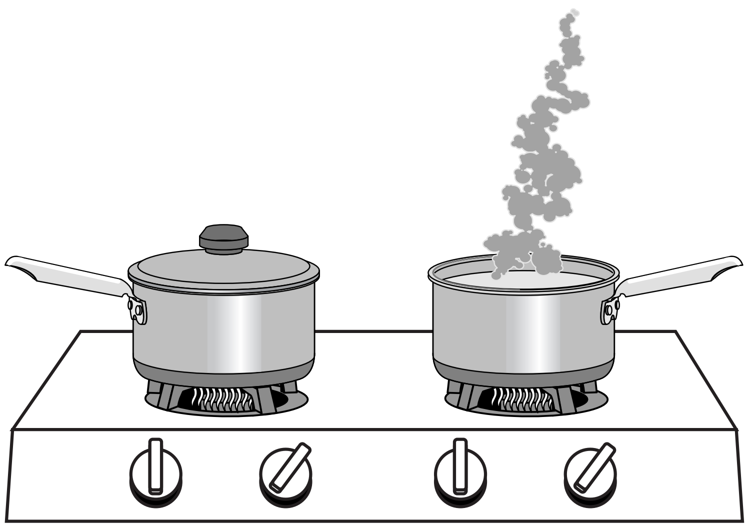
There are many different ways to find answers in science. You can observe the world around you and write down what you see. You can experiment. You can even ask someone who is an expert.

### O.K., I'm a scientist. But where do I start?

It all begins with noticing something that makes you wonder. Wondering about things usually causes you to ask questions. You ask, "Why did that happen?" or "How does that work?" or "What makes this different?" Observing and then asking questions are the first steps in getting started as a scientist.

### I wonder about things. I ask questions. What's next?

Whoa! Not so fast! Let's talk about something that makes me wonder. I've noticed that a pot of water covered with a lid boils faster than a pot of water without a lid. This makes me think that the lid helps trap heat inside the pot. I wonder whether I could use a lid or a cover to trap heat from the sun.



The water in the covered pot boils first.

Let's ask a question. How about: "Can a jar with a cover trap more heat from the sun than a jar without a cover?"

### How can we find out the answer to your question?

We need a plan. First of all, let's change my question into a statement that we can test. A statement that can be tested is called a *hypothesis*.

How about this for our hypothesis? A jar with a cover traps more heat from the sun than a jar without a cover. This is a statement that we can test, so it's a hypothesis.

**Did you know?**

Some scientists have made great discoveries by accident. Alexander Fleming discovered a lifesaving medicine called penicillin when he accidentally let a mold grow in his lab.

### Can you give me an example of a statement that isn't a hypothesis?

Sure! How about this one? Tomatoes taste better than green beans. We can't test this statement in science because it's an opinion. Some people might agree with it, and some might not. We can't test a statement if we can't collect facts about it, so it's not a hypothesis. In this case we could collect only opinions about the statement.

### Why do we have to test a hypothesis?

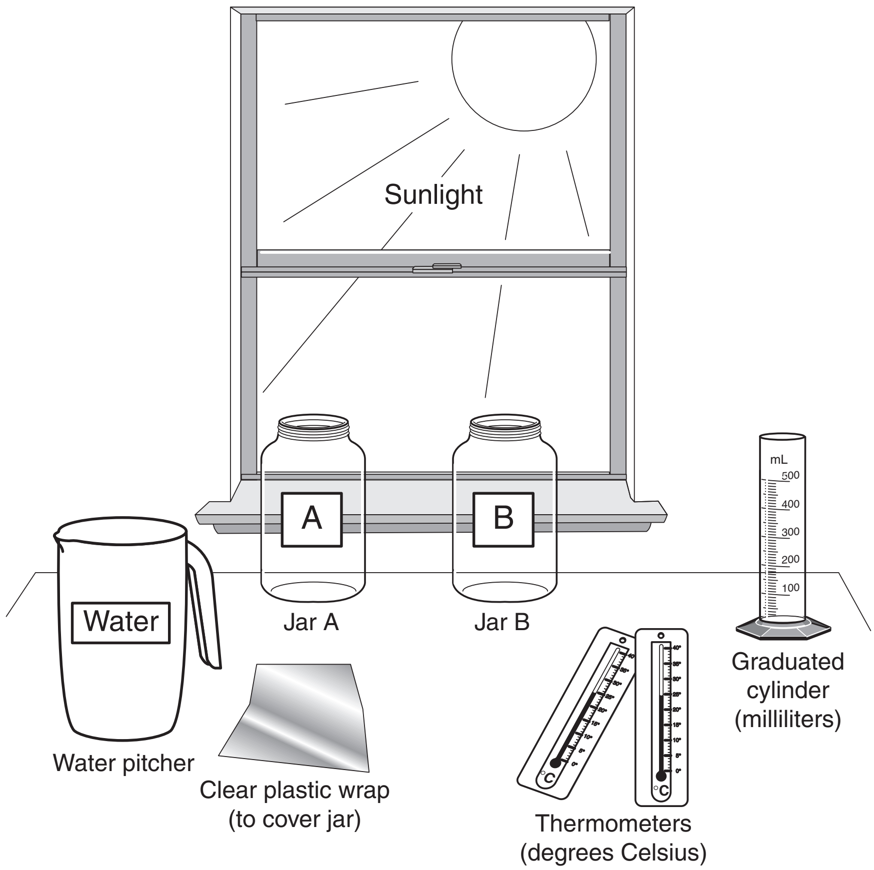
A hypothesis is really just a reasonable guess. It tells what you think will happen. When you test your hypothesis, you gather data, or information. You can then study this information to decide whether it supports your hypothesis.

### O.K., so we're going to test our hypothesis. How are we going to do that?

We're going to conduct an experiment. Let's look at our hypothesis again. A jar with a cover traps more heat from the sun than a jar without a cover.

Scientists must choose the right equipment and materials for an experiment. Let's think about the materials we might need. From the hypothesis I see that we will need jars, a cover for one of the jars, sunlight, and something to measure heat with. A *thermometer* measures temperature, and temperature is related to heat. Let's use a thermometer!

Let's also put something inside the jars to hold heat. Water is a good choice. We'll need something to measure the amount of water, such as a graduated cylinder or a metric measuring cup.




**The thermometers measure temperature in degrees Celsius, and the graduated cylinder measures volume in milliliters. Why can't we just use a Fahrenheit (°F) thermometer and measure the water in ounces (oz)?**

I'm glad you asked. Scientists all around the world make their measurements in *SI units*, such as degrees Celsius and milliliters. SI units are used worldwide and are commonly called metric units. If all scientists use the same measurement system, anyone can understand their experiments, no matter what part of the world they live in. Using the same measurement system is kind of like speaking the same language.

Many people in the United States use customary units, such as degrees Fahrenheit and ounces. You probably use customary units at home. But scientists, even scientists in the United States, use the SI system.

**Did you know?**

"SI units" comes from French and stands for Système International d'Unités, the official name of the metric system.

Objective 1

**Remember!**

Mass is a measure of the amount of matter an object contains. Volume is the amount of space an object takes up.

## What are some of the basic units of measurement in the SI system?

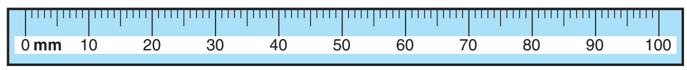
In the SI system, length is measured in meters, mass is measured in grams, and volume is measured in liters.

The tables show some SI units of length, mass, and volume.

### Units in the SI System

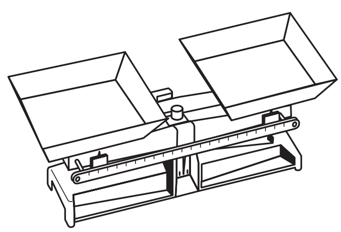
**Length**

| Smaller Unit | Basic Unit | Larger Unit |
|---|---|---|
| millimeter (mm)<br>1,000 mm = 1 m | meter (m) | kilometer (km)<br>1 km = 1,000 m |

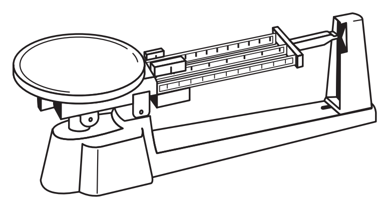



**Mass**

| Smaller Unit | Basic Unit | Larger Unit |
|---|---|---|
| milligram (mg)<br>1,000 mg = 1 g | gram (g) | kilogram (kg)<br>1 kg = 1,000 g |



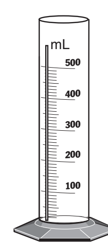
Double-pan balance



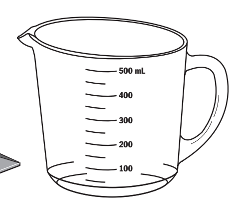
Triple-beam balance

**Volume**

| Smaller Unit | Basic Unit |
|---|---|
| milliliter (mL)<br>1,000 mL = 1 L | liter (L) |




Graduated cylinder




Measuring cup

The SI system is based on the number 10 and multiples of 10, such as 100 and 1,000. This makes it easy to change from one unit to another unit.

For ordinary lab measurements, scientists measure temperature in degrees Celsius (°C). The freezing temperature of water is 0°C, and the boiling temperature of water is 100°C.

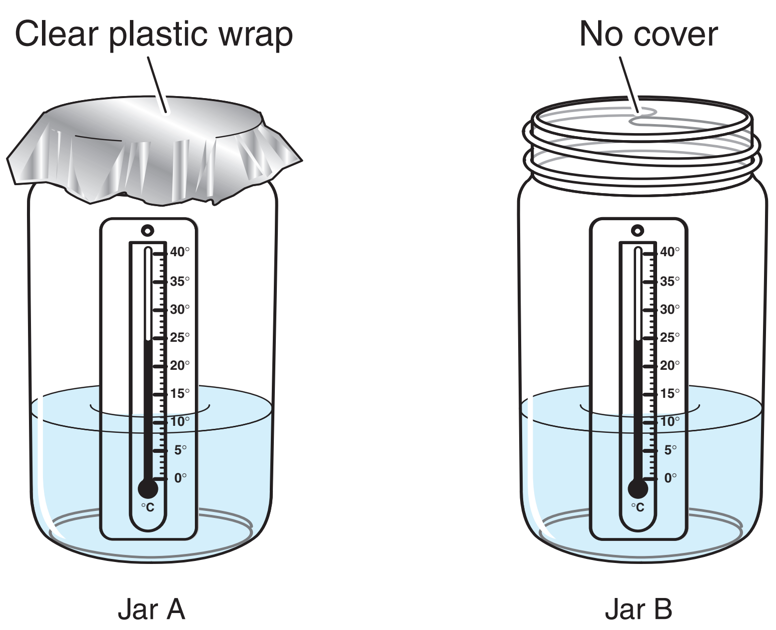
### Let's get back to our experiment. How are we going to use our materials to test our hypothesis?

We want to find out whether a jar that is covered will trap more heat from the sun than a jar that is not covered. So let's set up two jars in exactly the same way. The only difference between the two jars will be that one will be covered and one won't.

Let's get busy. Here are the steps we'll follow.

- Create a table in which to record data. Our table will need spaces for us to write down the temperatures of each jar and the times the temperatures were measured.
- Place a thermometer in equal amounts of water in each jar.
- Cover the top of one jar with clear plastic wrap.
- Place both jars outside in bright sunlight.
- Measure the temperature of the water in each jar and then measure the temperature again every five minutes for a total of 30 minutes. Remember to record the numbers in the data table.

**Experimental Setup**




### O.K., let's do it! Which one of us is going to write down our data?

You take the first measurements. I want to watch a scientist at work!

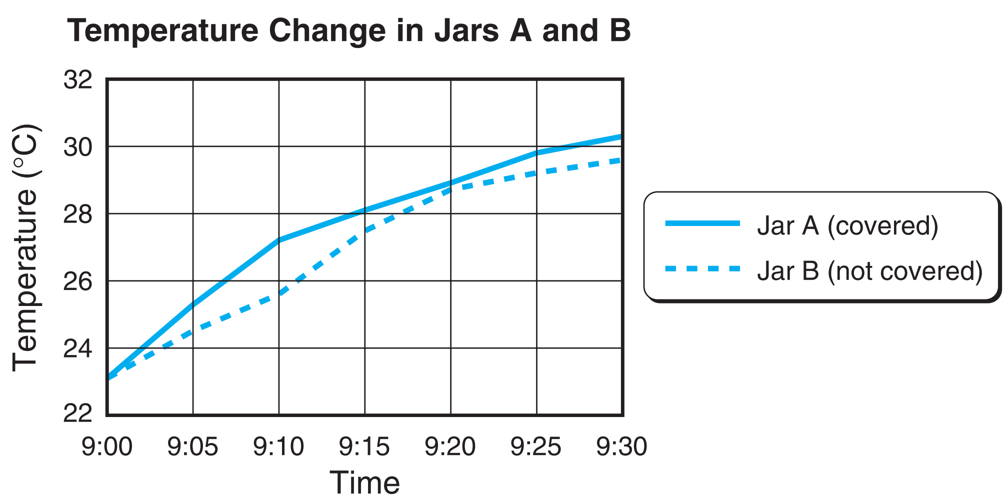
## Wow! Look at the data we collected! Now we have lots of numbers. What do we do with them?

Now that we have data, we will analyze, or study, our results. One of the ways scientists look at their data is by making graphs or charts. Let's use the data from our table to make a line graph. A line graph will help us compare the temperatures of the two jars. *Line graphs* are used to compare changes in data as time passes.

Here is our data table.

| Time | Temperature | |
|---|---|---|
| | Jar A (covered) | Jar B (not covered) |
| 9:00 | 23.1°C | 23.1°C |
| 9:05 | 25.3°C | 24.5°C |
| 9:10 | 27.2°C | 25.6°C |
| 9:15 | 28.1°C | 27.5°C |
| 9:20 | 28.9°C | 28.7°C |
| 9:25 | 29.8°C | 29.2°C |
| 9:30 | 30.3°C | 29.6°C |

Here is how these data look on a graph.




## The graph shows that the temperature of the covered jar was higher than the temperature of the uncovered jar. So now what?

Now we say that the evidence from our experiment supports our hypothesis that a jar with a cover will trap more heat from the sun than a jar without a cover.

### Does that mean our hypothesis is true?

Not necessarily. The temperature difference between the two jars wasn't very much. And we performed only one experiment. Scientists often repeat their experiments to make sure that they get the same results each time.

We can't say that our hypothesis is true. But we can say that our hypothesis is supported by our data.

### I'm glad our data supported our hypothesis. All of this could have been for nothing!

Not at all! Even when a hypothesis is not supported by the data, we still learn something. We learn that our hypothesis is probably false. A scientist would go back and think about the hypothesis, look at how the experiment was set up, and then try again.

### What else can we learn from our jar experiment?

We can make an *inference*. At the beginning of the experiment, the only difference between the jars was that Jar A was covered. At the end of the experiment, Jar A was warmer than Jar B. We can infer that Jar A was warmer because it was covered. The cover helped keep heat from escaping from Jar A, much like the lid on a pot keeps heat from escaping.

**Remember!**

An inference is a reasonable conclusion based on what you observe.

### This is super! In one day I did an experiment and became a scientist!

You have become something else too. You have become a model builder!

### A model builder? I don't remember putting any model airplanes together. What are you talking about?

I'm not talking about model airplanes. I'm talking about scientific models. Models help scientists understand parts of the natural world that are difficult to study directly.

The natural world is often very complicated. A model is simple and cannot include everything that is in the natural world. For this reason, models have weaknesses. The more closely a model represents the natural world, the better the model.

**Model of Earth**

This is a model of Earth. The planet Earth is much too big for us to observe completely. For this reason, a globe can make it easier to learn about Earth.

### So what kind of model did I build?

You made a simple model of Earth's atmosphere! The atmosphere helps trap heat from the sun and keep it from escaping Earth. Your covered jar also trapped heat from the sun. So you could use Jar A as a model for Earth's atmosphere.

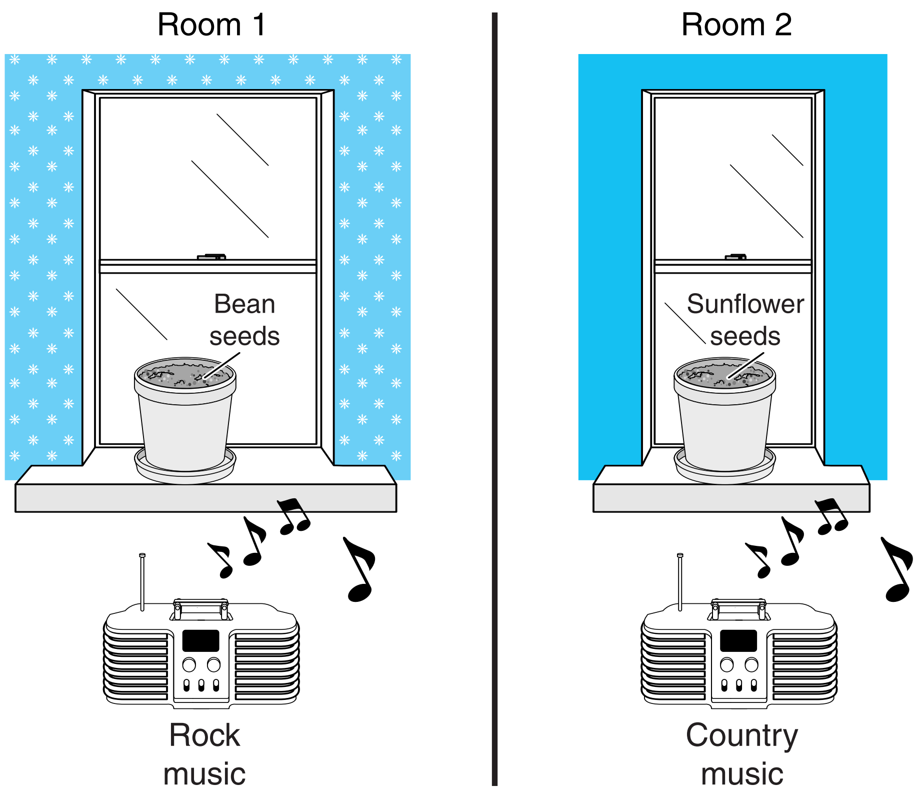
**Did you know?**

If the atmosphere didn't trap heat from the sun, Earth's average temperature would be about -18°C, which would be well below freezing.

**Do scientists ever make mistakes?**

Of course! Just like everyone else, scientists make mistakes. Let's look at one experiment that wasn't planned very well.

Suppose some students wanted to test whether different types of music could make plants grow taller. They planted five bean seeds in one pot and five sunflower seeds in another pot. They put the pots in different rooms and played a different type of music in each room.




After two weeks the students found that the plants in Room 1 had grown taller than the plants in Room 2. They concluded that rock music makes plants grow taller than country music.

Do you see any problems with the students' experiment?

### Yeah! They should have used the same type of seeds in each pot, right?

Right! The plants in Room 1 might have grown taller than the plants in Room 2 because the students used a different type of seed in each room. Also, the window in Room 1 is larger than the window in Room 2. The plants in Room 1 might have grown taller because they got more sunlight.

There are at least three possible reasons for the difference between the heights of the plants: (1) the type of seed, (2) the amount of sunlight, and (3) the type of music. The students have no way of knowing which of these affected the plants' growth.

### How could the students have made their experiment better?

They should have done a better job of controlling *variables*. A variable is something that you can change in an experiment. For example, variables in the students' experiment include type of seed, amount of light, type of music, amount of water, and so on.

Because the students wanted to know how different types of music affect plant growth, they should have kept all the variables the same except for the type of music. They should have made sure that all the plants received the same amount of light, and they should have used the same type of seeds in each pot.

Another way the students could have improved their experiment is by adding a third group of plants and growing them in a quiet room. This third group would have been a *control group*. The control group would have shown the students how tall the plants grow without music. They could have compared the results for the first two groups to this control group.

### What about our heat-trapping experiment with the jars? Did we control variables?

Yes, we did. The only variable we changed was whether the jars were covered. We made sure the jars had the same shape and size, the same amount of water, and the same amount of sunlight. We know that any differences in the temperatures of the jars were probably because Jar A had a cover and Jar B did not.