

# Tools of the Scientist

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## Unit Lessons

1. What is science?
2. What is the metric system?
3. How heavy is it?
4. How do we measure size?
5. What is a microscope?
6. What are the parts of a compound microscope?
7. What else should you know about the compound microscope?
8. How can we make a microscope slide?

## Goals and Objectives

After completing this unit, you should be able to:

- explain why controlled experiments are important in the scientific method.
- name the basic units and prefixes used in the metric system.
- explain the difference between a simple and a compound microscope.
- name the parts of a compound microscope and describe their functions.
- find the magnifying power of a microscope.
- describe how a wet mount is made.

# What is science?



**What is science?** The word science (SY-units) comes from the Latin word meaning "to have knowledge." Science is a carefully organized collection of knowledge about the world around us. It is also a way of finding out why things happen the way they do. It is a way of solving problems by testing possible answers to see if they work. The knowledge of science is based on observations and tests.

▶ **What is science?**

**What is biology?** As more and more has been learned about the world around us, scientists have had to choose particular subjects to study. There is too much scientific information for one person to know it all. The branch of science that deals with the study of living things is called biology (by-OL-uh-jee). This branch of science includes all kinds of knowledge about living things.

▶ **What is biology?**

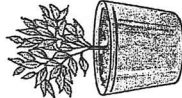
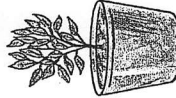
**The scientific method.** When scientists try to solve a problem or answer a question, they use the scientific method. It helps them to organize their work. It also helps them to check their results and make sure they are correct. The scientific method is a step-by-step way of studying a problem. It is mainly common sense. You have probably used the scientific method many times without knowing it.

▶ **What is the scientific method?**

**The controlled experiment.** Scientists often do experiments (ik-SPER-uh-ments), or tests, to find out why things happen. A very useful kind of experiment in biology is called a controlled experiment.

In a controlled experiment, two experiments are set up. Everything about the two experiments is exactly the same. One experiment is left alone. This experiment is called the control. In the other experiment, one thing is changed. Both experiments are

CONTROL



TEST PLANT



In this experiment, two plants of the same kind and size are placed in identical pots. Both plants are given the same amount of water. Both plants receive the same amount of light. However, fertilizer is added to the soil of the experimental plant. The control receives no fertilizer. At the end of the experiment, the plants are measured. The experimental plant is larger than the control plant. This difference must be due to the fertilizer. All other conditions were the same.

**scientific method**

a step-by-step way of studying a problem  
experiment (ik-SPER-uh-ment)  
a test used to discover something

**controlled experiment**

two experiments exactly alike except for one change in one of them  
**control**  
in a controlled experiment, the experiment in which no change is made

**ANSWER THESE**

1. Science
  - a. is based on ideas only
  - b. is an organized collection of knowledge
  - c. never uses experiments
2. Biology is the study of
  - a. all living things
  - b. animals only
  - c. rocks
3. The scientific method
  - a. is used only by scientists
  - b. is a step-by-step way of studying a problem
  - c. cannot be used in biology

**NOW TRY THIS**

See how many four-letter words you can make using the letters in the word **EXPERIMENT**.

**FINDING OUT MORE**

Plants need sunlight to grow. Make up a controlled experiment that could show that this is true. In your experiment, describe what you would do and why. Be sure to state which part of your experiment is the control.

then observed. Any differences in the results of the two experiments must be due to the one thing that was changed.

▶ **What kind of experiment is useful in biology?**

**WHAT YOU LEARNED**

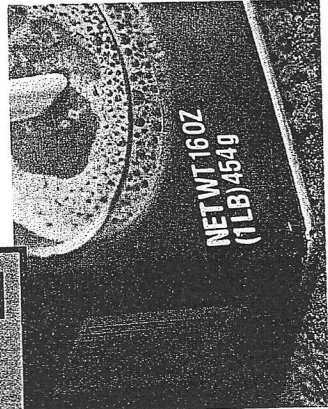
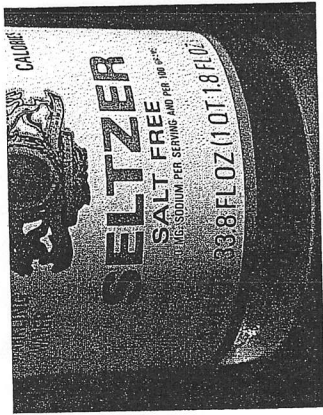
1. Science is a carefully organized collection of knowledge about the world around us.
2. Biology is the study of living things.
3. The scientific method is a step-by-step way of studying a problem.
4. A controlled experiment is a useful kind of experiment in biology.

**SCIENCE WORDS**

science (SY-units)  
a carefully organized collection of knowledge about the world around us  
biology (by-OL-uh-jee)  
the study of living things



## What is the metric system?

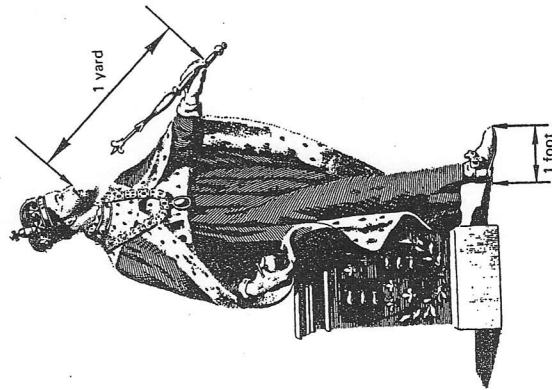


**Units of measurement.** In our everyday system of measurement, we measure length in inches, feet, yards, and miles. Weight is measured in ounces, pounds, and tons. Volume is measured in ounces, pints, quarts, and gallons. Inches, pounds, and quarts are units (YOU-nits) of measurement. A unit of measurement is a fixed amount with which things are measured.

▶ What is a unit of measurement?

**Making measurements.** In the past, people used many different units for measuring things. For example, in England, a yard was the distance from the king's nose to the end of his hand. The length of his foot was a foot. The inch was the distance between two knuckles. The height of a horse was measured in hands.

Can you see any problems with this way of measuring? Since people are of different



sizes, measurements were not always the same. A system of measurement that was always the same was needed.

In 1791, French scientists presented a new system of measurement. It is called the metric system (MEH-trik SIS-tem). Before long, people in many parts of the world began using the metric system. Today, all scientists use the metric system in making measurements.

▶ What system of measurement do scientists use?

**Why is the metric system better?** In the system of measurement that uses inches, feet, and miles, there is no particular relationship between the units. For example, in measuring length, there are 12 inches in a foot. There are 3 feet in a yard. There are 1,760 yards in a mile. This makes it hard to change from one unit of length to another. It is also hard to remember.

The scientists who worked out the metric system made it very easy to change from one unit to another. In the metric system, each unit differs from the next smaller or larger one by ten times. To change from one metric unit to a larger or smaller one, you just multiply or divide by ten. The metric system is easy to use because there is a simple relationship between the units in the system.

▶ Why is the metric system easy to use?

### WHAT YOU LEARNED

1. A unit of measurement is a fixed amount with which things are measured.
2. Scientists use the metric system in making measurements.
3. The metric system is easy to use because there is a simple relationship between the units of the system.

### SCIENCE WORDS

**unit of measurement (YOU-nit)**  
a fixed amount with which things are measured

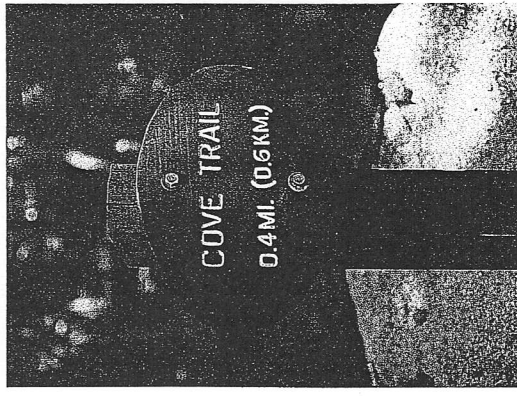
**metric system (MEH-trik SIS-tem)**  
a system of measurement

### ANSWER THESE

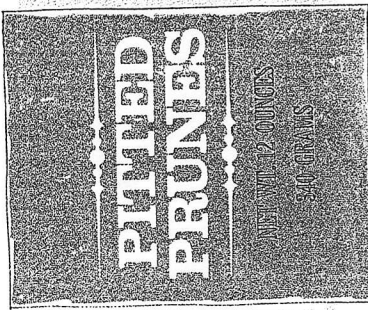
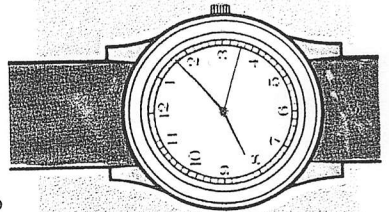
1. An example of a unit of measurement is a(n)
  - a. bottle
  - b. hamburger
  - c. inch
2. The system of measurement used by scientists is the
  - a. English system
  - b. metric system
  - c. foot

### FINDING OUT MORE

In most countries, the metric system is used in daily life. The United States is one of the few countries that does not use it completely. But change is coming. This country is slowly changing over to the metric system. You will use the metric system in your study of science.



# How heavy is it?



SEEDLESS  
**raisins**  
NET WT. 15 OZ. 425 GRAMS

**How much?** When you shop, you want to get the most for your money. When you buy chopped meat, you want to know how much meat is in the package. The label on the package tells you how much it weighs. Weight is one way of describing the amount of something. Weight is one of the properties of matter that can be measured. Length, area, and volume are also properties we can measure. To find out things about matter, we must describe its properties. Many properties can be measured.

► What are some properties of matter that we can measure?

**Units of mass.** We buy meat by the pound. The pound is a unit of weight. Scientists do not use weight to mean the amount of something. They use the word mass. They measure mass in grams. The gram is a unit of mass in the metric system. A nickel has a mass of about 5 grams. Weight and mass are related, but they are not the same.

► What unit is used to measure mass in the metric system?

**Cutting it to size.** For large objects, the gram may be too small. For small objects, the gram may be too big. The mass of an insect may be only 1/100 of a gram. The metric system can solve this problem.

PREFIX	MEANING
giga (G)	one billion (1,000,000,000)
mega (M)	one million (1,000,000)
kilo (K)	one thousand (1,000)
hecto (H)	one hundred (100)
deca (D)	ten (10)
deci (D)	one-tenth (1/10)
centi (C)	one-hundredth (1/100)
milli (M)	one-thousandth (1/1,000)
micro (μ)	one-millionth (1/1,000,000)
nano (N)	one-billionth (1/1,000,000,000)

Look at the table. A prefix (PREE-*fix*) can be used to change the size of a unit. It can make the unit larger or smaller. "Kilo-" (KILL-uh) is a prefix that means 1,000. A kilogram (KILL-uh-gram) is 1,000 grams. The mass of large objects is measured in kilograms. A person with a mass of 75,000 grams has a mass of 75 kilograms. "Centi-" (SEN-tih) is a prefix meaning 1/100. An insect with a mass of 1/100 of a gram has a mass of 1 centigram.

► What is a kilogram?

**Just a second!** In daily life, we use many different units to measure time. The second, the minute, the hour, the day, the year, and the century (100 years) are units of time. The second is the main unit of time in the metric system.

► What is the unit for measuring time in the metric system?

## WHAT YOU LEARNED

1. The amount of matter in an object is called its mass.
2. In the metric system, mass is measured in grams.
3. Prefixes are used to name larger or smaller units in the metric system.
4. Time is generally measured in seconds in the metric system.

## SCIENCE WORDS

**gram**  
a unit of mass in the metric system

**mass**  
the amount of matter in an object

**kilogram (KILL-uh-gram)**  
1,000 grams

## ANSWER THESE

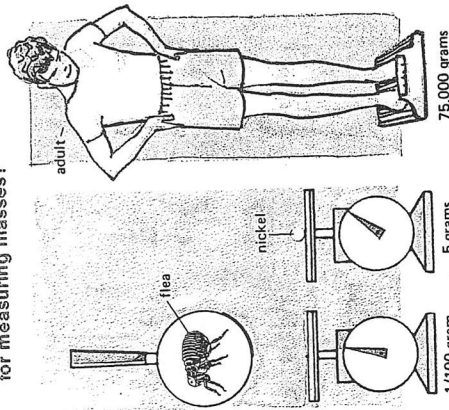
1. Write the following masses in order from the smallest to the largest.  
milligram  
kilogram  
microgram  
hectogram  
centigram  
gram
2. Use the table of prefixes to find the meaning of each of these:  
microsecond  
millisecond  
megaton

## NOW TRY THESE

1. How many seconds are there in a century? Give your answer in megaseconds.
2. Scientists sometimes measure the cost of scientific equipment in "megabucks." A large atom-smasher may cost 500 megabucks to build. What do you think that means?

## FINDING OUT MORE

The International Bureau of Weights and Measures is located near Paris, France. The standard unit of mass is kept there. This mass is exactly 1,000 grams, or 1 kilogram. Each nation keeps a copy of this mass in its own national laboratory. This is done so that scientists all over the world can be sure they are measuring mass in the same units. The standard kilogram is made of a platinum-iridium alloy that will not rust. It is carefully protected against damage. What might happen if this standard mass became scratched?

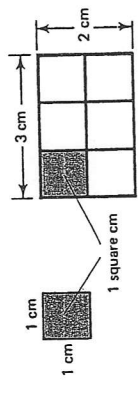


# How do we measure size?



**Measuring length.** In the metric system, we measure length and distance in a unit called the meter (MEE-ter). We use prefixes to make larger and smaller units of length. A kilometer (KILL-uh-mee-ter) is 1,000 meters. A centimeter (SEN-tih-mee-ter) is 1/100 of a meter. A millimeter (MILL-ih-mee-ter) is 1/1000 of a meter. The table compares the units of length.

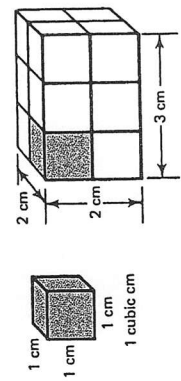
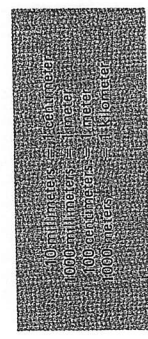
▶ What is the unit of length in the metric system?



Length x Width = Area  
 $3 \text{ cm} \times 2 \text{ cm} = 6 \text{ square centimeters}$

**Measuring area.** Look at the drawing of the square. Each side of the square is 1 centimeter long. The area of the square is 1 square centimeter. Now look at the drawing of the rectangle. Its length is 3 centimeters. Its width is 2 centimeters. You can see that the rectangle contains 6 square centimeters. Its area is 6 square centimeters. You can find the area of a rectangle by multiplying its length by its width.

▶ How can we find the area of a rectangle?



Length x Width x Height = Volume  
 $3 \text{ cm} \times 2 \text{ cm} \times 2 \text{ cm} = 12 \text{ cubic centimeters}$

**Measuring volume.** Look at the drawing of the cube. Each edge of the cube is 1 centimeter long. The volume of the cube is 1 cubic centimeter. Now look at the drawing of the box. Its length is 3 centimeters. Its width is 2 centimeters. Its height is 2 centimeters. Its volume is 12 cubic centimeters. The volume of a box can be found by multiplying its length by its width by its height.

▶ How can we find the volume of a box?

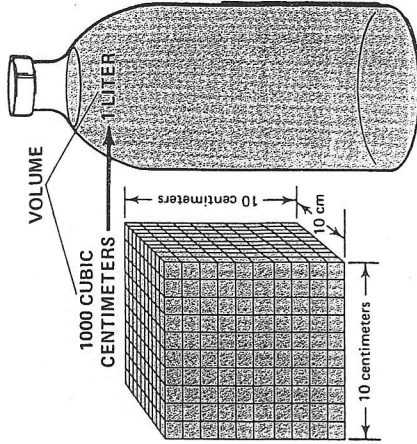
**Volume of liquids.** Volume is measured in cubic centimeters. Volume can also be measured in units called liters (LEE-ter). The volume of liquids is often measured in liters. A liter is the same as 1,000 cubic centimeters. A box that is 10 centimeters on each side has a volume of 1,000 cubic centimeters ( $10 \times 10 \times 10 = 1,000$ ). One liter of a liquid will exactly fill the box. A milliliter (MILL-ih-lee-ter) is 1/1000 of a liter. A milliliter is the same as 1 cubic centimeter.

▶ How many cubic centimeters are there in 1 liter?

**Abbreviating units.** Milligram, kilometer, and cubic centimeter are long words. It takes a lot of space and a lot of time to write them out. We abbreviate (uh-BREE-vee-ate), or shorten, the names of units. For example, km is the abbreviation for kilometer. To abbreviate units of area and volume, we use a small 2 to show square units and a small 3 to show cubic units. To abbreviate square centimeters, we write  $\text{cm}^2$ . To abbreviate cubic centimeters, we write  $\text{cm}^3$ . The table shows the abbreviations for units in the metric system.

▶ How would we abbreviate 100 cubic centimeters?

NAME OF UNIT	ABBREVIATION
gram	g
kilogram	kg
milligram	mg
meter	m
kilometer	km
centimeter	cm
millimeter	mm
square centimeters	$\text{cm}^2$
cubic centimeters	$\text{cm}^3$
liter	l
milliliter	ml



### WHAT YOU LEARNED

- The unit of length is the meter.
- Area is measured in square units.
- Volume is measured in cubic units.
- A liter is the same as 1,000 cubic centimeters.
- Units can be abbreviated.

### SCIENCE WORDS

- meter (MEE-ter) the unit of length in the metric system
- kilometer (KILL-uh-mee-ter) 1,000 meters
- centimeter (SEN-tih-mee-ter) 1/100 of a meter
- millimeter (MILL-ih-mee-ter) 1/1000 of a meter
- liter (LEE-ter) 1,000 cubic centimeters

### ANSWER THESE

- The unit of length is the
  - meter
  - liter
  - kilogram
- The volume of liquids is measured in
  - square centimeters
  - cubic liters
  - liters
- Width X height X length of a box equals its
  - area
  - weight
  - volume

## What else should you know about the compound microscope?

**Care of the microscope.** The microscope should always be handled with care. To carry the microscope, use one hand to hold the arm. Place your other hand under the base.

► **How is the microscope carried?**

**Before using the microscope.** A few important checks should be made before you use the microscope.

1. Are the lenses clean?

To clean the lenses of a microscope, use lens paper ONLY. Any other kind of paper may scratch the lenses. Gently wipe the eyepiece and the objective lenses.

► **Why must lens paper be used to clean the lenses?**

2. Are the objectives in place?

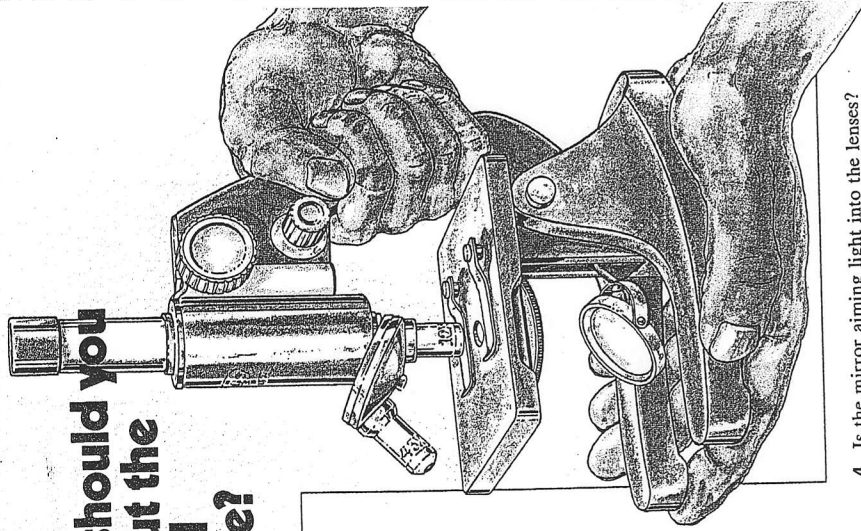
There are two objectives in the nosepiece. The low-power objective is usually marked 10X. The high-power objective may be marked 43X. The low-power objective should first be clicked into place over the hole in the stage.

► **Which objective should be placed directly over the hole in the stage first?**

3. Is the diaphragm open?

Light must travel through the object you wish to look at. If light does not come through, you will not be able to see anything. Move the diaphragm to its largest opening.

► **Why must the diaphragm be open?**



4. Is the mirror aiming light into the lenses?

The microscope must be placed so that light can hit the mirror. Look through the eyepiece. Move the mirror until you see a bright circle of light.

► **How does light enter the microscope?**

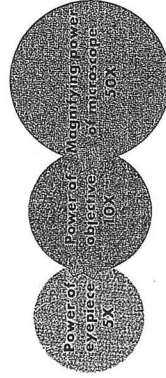
**Magnifying power.** Look for a number and the letter "X" on the eyepiece of the microscope. You may see 5X. This means that the eyepiece makes an object look five times larger than it is. Its magnifying power is five times.

Now look at the low-power objective. You may see 10X. This means that the magnifying power of the low-power objective is ten times.

When you look at the high-power objective, you may see 43X. This objective will magnify an object forty-three times.

To find the magnifying power of a compound microscope, multiply the power of the eyepiece by the power of the objective you are using.

For example, suppose your microscope has an eyepiece marked 5X, and a low-power objective marked 10X. What is the magnifying power when you are using the low-power objective? Here is how you find out:

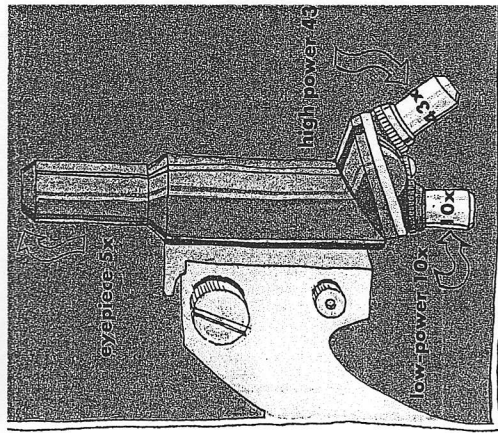


The magnifying power is 50X. This means that the object you are viewing looks fifty times larger than its real size.

► **Suppose you are using a high-power objective that is marked 43X. The eyepiece is marked 5X. What is the magnifying power of this microscope?**

### WHAT YOU LEARNED

1. Carry the microscope by holding the arm and the base.
2. Use only lens paper to clean the lenses.
3. The diaphragm allows light to travel through the lenses.
4. The mirror aims light through the diaphragm.
5. The magnifying power of a compound microscope is found by multiplying the power of the eyepiece by the power of the objective you are using.



### SCIENCE WORD

**magnifying power**  
the number of times a microscope magnifies an object

### ANSWER THESE

1. What would you do to allow less light to enter a microscope?
2. How would you get the greatest magnifying power from a compound microscope?
3. Why is it important to handle the microscope carefully?

### NOW TRY THESE

1. The microscope should be carried by the
  - a. arm and stage
  - b. arm and base
  - c. eyepiece and base
2. A magnifying power of 430X means that an object
  - a. is 430 times larger than its normal size
  - b. appears 430 times larger than its normal size
  - c. appears 430 times smaller than its normal size
3. The function of the mirror is to
  - a. magnify the object you are viewing
  - b. aim light through the diaphragm
  - c. hold down the object you are viewing