Name _____ Class _____ Date _____

CHAPTER 1 The Nature of Life Science

SECTION 3

Tools and Measurement

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- How do tools help scientists?
- How do scientists measure length, area, mass, volume, and temperature?

California Science Standards

7.7.a

Select and use appropriate tools and technology (including calculators, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.

What Tools Do Scientists Use?

The application of science for practical purposes is called **technology**. Life scientists can use technology to find information and solve problems in new ways. New technology can allow scientists to get information that was not available before.

STUDY TIP

Compare As you read this section, make a table that compares how scientists measure length, area, mass, volume, and temperature. Include the tools and units of measurement that scientists use.

CALCULATORS AND COMPUTERS

Scientists use many different tools to analyze, or examine, data. Calculators can help scientists do calculations quickly. Computers are very important tools for collecting, storing, and studying data.

BINOCULARS

Scientists can use tools to help them see objects clearly. For example, it is not always easy or safe to get close to an organism that you are studying. *Binoculars* are a tool that scientists can use to help them see things that are far away.

Binoculars help scientists make observations when they cannot get close to their subject.

TAKE A LOOK

1. Explain Why would a scientist use binoculars?

To view something in the wild without affecting its behavior.

COMPOUND LIGHT MICROSCOPES

Scientists use microscopes to see things that are very small. One kind of microscope is a **compound light microscope**, which is a tool that magnifies small objects. It has three main parts: a stage, a tube with two or more lenses, and a light. An item is placed on the stage. Light passes through the item. The lenses help to magnify the image of the item.

CALIFORNIA STANDARDS CHECK

7.7.a Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.

Word Help: appropriate
correct for the use; proper

Word Help: technology
tools, including electronic products

Word Help: computer
an electronic device that stores, retrieves, and calculates data

Word Help: data
facts or figures; information

2. Identify A scientist wants to look at a small, living cell. Should the scientist use a compound light microscope or an electron microscope? Explain your answer.

A light microscope should be used. This way the cell can be kept alive and the movement of internal parts can be seen.

Not an electron microscope because that would kill the cell.

Critical Thinking

3. Predict Consequences What could happen if scientists used many different systems of measurement to record their data?

Their data may be falsely recorded without the correct units and when converted there may become a mathematical error.

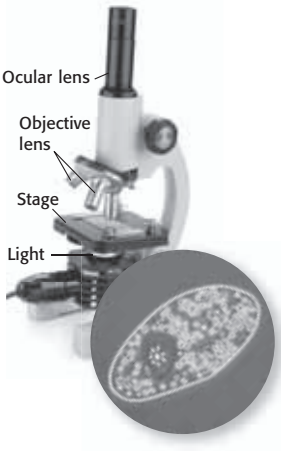
ELECTRON MICROSCOPES

Electron microscopes use tiny particles called *electrons* to produce magnified images. Electron microscopes make clearer and more detailed images than light microscopes do. However, unlike light microscopes, electron microscopes cannot be used to study things that are alive.

How Do Scientists Measure Objects?

Scientists make many measurements as they collect data. It is important for scientists to be able to share their data with other scientists. Therefore, scientists use units of measurement that are known to all other scientists. One system of measurement that most scientists use is called the International System of Units.

Compound Light Microscope Light passes through a specimen and produces a flat image.



Transmission Electron Microscope Electrons pass through the specimen and produce a flat image.

Scanning Electron Microscope Electrons bounce off the surface of the specimen and produce a three-dimensional (3-D) image.

THE INTERNATIONAL SYSTEM OF UNITS

The *International System of Units*, or *SI*, is a system of measurement that scientists use when they collect data. This system of measurement has two benefits. First, scientists around the world can share and compare their data easily because all measurements are made in the same units. Second, SI units are based on the number 10. This makes it easy to change from one unit to another.

It is important to learn the SI units that are used for different types of measurements. You will use SI units when you make measurements in the science lab.

LENGTH

Length is a measure of how long an object is. The SI unit for length is the meter (m). Centimeters (cm) and millimeters (mm) are used to measure small distances. There are 100 cm in 1 m. There are 1,000 mm in 1 m. Micrometers (µm) are used to measure very small distances. There are 1 million µm in 1 m. Rulers and meter sticks are used to measure length.

Length Tools: ruler or meter stick	SI unit: meter (m) kilometer (km) centimeter (cm) millimeter (mm)	1 km = 1,000 m 1 cm = 0.01 m 1 mm = 0.001 m 1 µm = 0.000001 m

TAKE A LOOK

4. Identify What is the SI unit for length?

the meter
it is longer than a yard

AREA

Area is a measure of how much surface an object has. For most objects, area is calculated by multiplying two lengths together. For example, you can find the area of a rectangle by multiplying its length by its width. Area is measured in square units, such as square meters (m^2) or square centimeters (cm^2). There are 10,000 cm^2 in 1 m^2. ☑

There is no tool that is used to measure area directly. However, you can use a ruler to measure length and width. Multiply these measurements to find area.

Area	square meter (m^2) square centimeter (cm^2)	1 cm^2 = 0.0001 m^2

READING CHECK

5. Explain How can you find the area of a rectangle?

measure the length and width
the the area = length X width

VOLUME

Volume is the amount of space an object takes up. You can find the volume of a box-shaped object by multiplying its length, width, and height together. You can find the volume of objects with many sides by measuring how much liquid they can push out of a container, as shown in the figure on the next page. Beakers and graduated cylinders are used to measure the volume of liquids. ☑

Volume is often measured in cubic units. For example, very large objects can be measured in cubic meters (m^3). Smaller objects can be measured in cubic centimeters (cm^3). There are 1 million cm^3 in 1 m^3. The volume of a liquid is sometimes given in units of liters (L) or milliliters (mL). One mL has the same volume as 1 cm^3. There are 1,000 mL in 1 L. There are 1,000 L in 1 m^3.

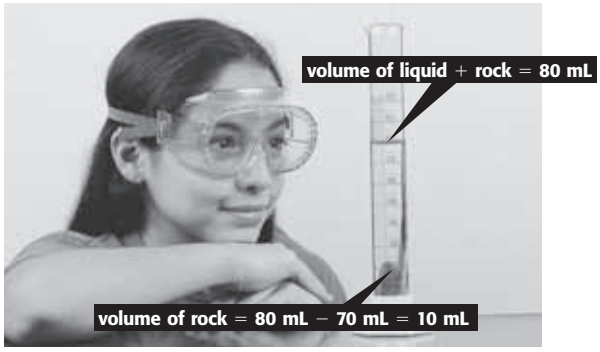
Volume Tools: graduated cylinder or beaker	cubic meter (m^3) cubic centimeter (cm^3) liter (L) milliliter (mL)	1 cm^3 = 0.000001 m^3 1 L = 0.001 m^3 1 mL = 1 cm^3

READING CHECK

6. Define What is volume?

the holding capacity if the object were a container.

You can find the volume of a more complicated object, such as this rock, by measuring how much liquid it pushes out of the way. The graduated cylinder has 70 mL of liquid in it before the rock is added.



The rock made the volume of material in the cylinder go up to 80 mL. The rock pushed 10 mL of liquid out of the way. The volume of the rock is 10 mL. Because 1 mL = 1 cm^3, the volume of the rock can also be written as 10 cm^3.

TAKE A LOOK

7. Explain How do you know that the rock in the figure has a volume of 10 mL?

The original volume of 70 mL went up to 80 mL with the rock. S0 80 - 70 = 10 mL is the additional volume gained from the rock.

MASS AND WEIGHT

Mass is the amount of matter in an object. The SI unit for mass is the kilogram (kg). The masses of large objects, such as people, are measured in kilograms. The masses of smaller objects, such as apples, are measured in grams (g) or milligrams (mg). There are 1,000 g in 1 kg. There are 1 million mg in 1 kg. Balances are used to measure mass.

Math Focus

8. Convert How many milligrams are there in 1 g?

1,000 mg = 1 g

Mass Tool: balance	SI unit: kilogram (kg) gram (g) milligram (mg)	1 g = 0.001 kg 1 mg = 0.000001 kg

READING CHECK

9. Compare How are mass and weight different?

Mass is a count of how much matter in the form of protons and neutrons that make up the whole object. This gives the object inertia (hard to shake back and forth).

Weight is only a measure of gravitational attraction between the planet and the object.
No planet = deep space = no weight

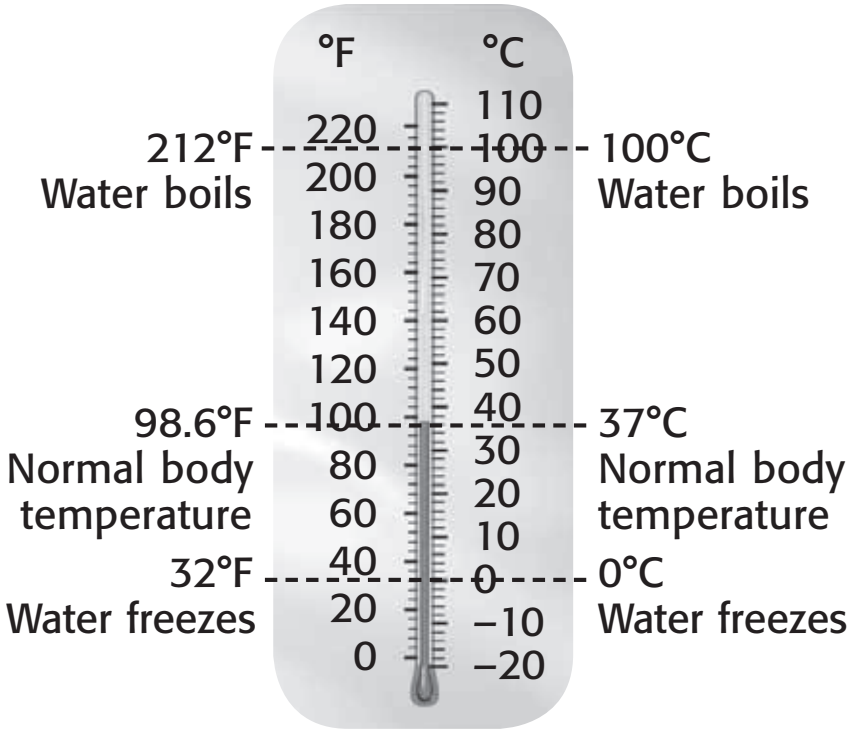
Weight is different from mass. **Weight** is a measure of the force of gravity on an object. The force of gravity is measured in newtons (N). The force of gravity changes depending on where you are located in the universe. Therefore, a person's weight changes from place to place. For example, you weigh more on Earth than on the moon, even though your mass is the same in both places. Spring scales are used to measure weight. ☑

TEMPERATURE

Temperature is a measure of how hot or cold an object is. The SI unit for temperature is the kelvin (K). However, most people are more familiar with other units of temperature. For example, most people in the United States measure temperatures in degrees Fahrenheit (°F). Scientists often measure temperatures in degrees Celsius (°C). Thermometers are used to measure temperature. ☑

Temperature Tool: thermometer	SI unit: kelvin (K) degrees Celsius (°C)	0°C = 273 K 100°C = 373 K

It is easy to change a temperature measurement from degrees Celsius to kelvins. You simply add 273 to the Celsius measurement. For example, 200°C + 200 + 273 = 473 K. It is more complicated to change measurements in kelvins or degrees Celsius to degrees Fahrenheit. That is why scientists do not measure temperatures in degrees Fahrenheit. ☑



This thermometer shows the relationship between degrees Fahrenheit and degrees Celsius.

READING CHECK

10. Define What is temperature?

Temperature is the average kinetic energy of the particles that make up and object. Hot objects have particles that are moving faster.

READING CHECK

11. Explain Why do scientists measure temperature in kelvins or degrees Celsius rather than degrees Fahrenheit?

The Kelvin scale represents all the degrees from absolute zero and up. It is the SI standard scale for temperature.

TAKE A LOOK

12. Identify What is normal body temperature in degrees Celsius?

37 degrees Celsius

Name _____ Class _____ Date _____

Section 3 Review

7.7.a 

SECTION VOCABULARY

area a measure of the size of a surface or a region

compound light microscope an instrument that magnifies small objects so that they can be seen easily by using two or more lenses

Wordwise The root *micro* means "small." The root *scope* means "an instrument for seeing or observing."

electron microscope a microscope that focuses a beam of electrons to magnify objects

mass a measure of the amount of matter in an object

temperature a measure of how hot (or cold) something is; specifically, a measure of the average kinetic energy of the particles in an object

technology the application of science for practical purposes; the use of tools, machines, materials, and processes to meet human needs

volume a measure of the size of a body or region in three-dimensional space

weight a measure of the gravitational force exerted on an object; its value can change with the location of the object in the universe

1. Describe You can find the volume of a box-shaped object by multiplying its length, width, and height together. How can you measure the volume of an object if it is not shaped like a box?

For irregular solids you can measure the volume by method of displaced liquid. First fill a graduated container with water (enough to submerge the object into). Next record the water level (this is the initial water volume). Then submerge the object completely under water. Now record the water level (this is the final water volume). To calculate the volume of the solid object, subtract initial from the final water volume.

2. Identify Fill in the table to show the tools you would use to carry out the measurements.

Task	Tool
Looking at something that is very small	microscope
Measuring how tall your friend is	two meter stick rulers, or a tape measure
Measuring how much water is in your glass	a graduated cylinder
Measuring the weight of a mouse	a spring scale

3. Identify What are two units that scientists use to measure temperature?

Kelvin and Celsius degrees