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CHAPTER

8 NUMBERS, WORDS, AND QUANTITIES

8-1 The Quantifying Sense

Whether you know it or not, you are constantly measuring, calculating, and quantifying the world around you. Even slang phrases such as *No way!* or *Awesome!* are measurements. *No way* simply means that there is a zero chance of something happening. *Awesome* means that something is really big or that it is really great in some way. Even a phrase such as *He loves her like crazy* indicates a quantity. *Like crazy* means a lot, or a great deal.

The word *quantity* probably makes you think of numbers. But quantifying is not just a matter of numbers. It is a certain sense or feel about the size, greatness, or amount of something. We can call it a **quantifying sense.** It does not have to involve numbers at all, as you can see from the examples in the last paragraph.

Even animals have a sense of quantity. Spiders tend to create a certain number of polygons when they spin their webs. And a sheep dog will know if one sheep in a large herd is missing. Whether in science or in other areas of our lives, we can better understand things if we examine them with an awareness of quantity.

In English there are many words that are used for quantifying. These words can be called **quantifiers.** Any word that represents how much, how often, how many, or how large is a quantifier. Think back to Chapter 1 in which you studied descriptions in great detail. Think about how difficult it would be to accurately describe an object without using any quantifiers. For instance, could you accurately describe a tree without saying how tall the tree is? Until now, you were probably not even aware of how often you use quantity words. Exercise 1 allows you to practice identifying quantifers.

When you think of quantity, you probably think of numbers. But quantifiers sometimes mix words with numbers. Numbers will be looked at more closely later in this chapter. For now, you should understand how numbers and words are used together. Scientific experiments often require exact measurements. Measurements are written as a number and a unit of measurement, such as 14 milliliters, 50 centimeters, or 20 milligrams. Measurements combine words (the units) with numbers (the exact quantity). Without the unit, the numbers are meaningless. Exercise 2 gives you practice combining words and numbers to quantify parts of your everyday life.

Exercise 1 Quantifiers

List all of the quantifiers in the passage found on the following page. Some of them are harder to spot than others. There may be more lines than you need.

Biomes

Earth is covered by hundreds of types of ecosystems. For convenience, ecologists divide these ecosystems into a few biomes. Biomes are areas that have distinctive climates and organisms. Each biome contains many individual ecosystems. Biomes are named according to their plant life because the plants that can grow in an area determine what other organisms can live there. But what determines which plants can grow in a certain area? The main determinant is climate. Climate refers to weather conditions in an area—temperature, precipitation, humidity, and winds—over a long period of time. Temperature and precipitation (rain, sleet, and snow) are the two most important factors in a region's climate.

(from Holt Environmental Science)

______________________ ______________________

______________________ ______________________

______________________ ______________________

______________________ ______________________

______________________ ______________________

______________________ ______________________

Exercise 2 Words and Numbers

Answer each of the following questions using a combination of words and numbers.

a. How often do you brush your teeth?

____

b. How much time do you spend watching television?

____

c. How much time do you spend on homework?

____

d. How big is your class?

____

Scalar Words

How often have you been asked to rate something on a scale of 1 to 10? You probably have been asked often. People like to measure things using scales. Of the many hundreds of words in the English language that can be used for quantifying, most (but not all of them) can be arranged on a scale from 0 percent to 100 percent. For example, the scale in **Figure 8-1** shows words used to explain *how often* or *how frequently* something happens. **Figure 8-2** gives another example using quantifiers that describe size.

0%	10–20%	30%–40%	50%	60–70%	80–90%	100%
never	rarely	seldom	sometimes	often	almost always	always

FIGURE 8-1 *How often* or *how frequently* something happens can range from *never* to *always*.

0%	10–20%	30%–40%	50%	60–70%	80–90%	100%
infinitely small	very small	small	medium	large	very large	the largest

FIGURE 8-2 Quantifiers to describe size can also be placed on a scale from 0 percent to 100 percent.

In fact, most other groups of quantifiers can be arranged in a similar way. These quantifiers might answer questions such as *how much, how many,* or *how fast.* Another example of quantifying things along a scale can be found in Chapter 7. In the chapter on hypotheses, you studied probability, or the question of how likely something is. Figure 7-3 showed a scale of probability words similar to the scales in Figures 8-1 and 8-2.

The kinds of words that fit on a scale can be called scale words or **scalar words.** There are certain patterns of words that serve as scalars. Some of these patterns involve suffixes attached to adjectives. An example of this pattern would be the suffixes *-er* and *-est.* The adjectives big, bigg*er,* and bigg*est* are scalar words. Another pattern involves adding scalar adjectives to quantifiers. For example, the descriptive word *interesting* can be made into a scalar quantifier by adding *less* or *more* to form *less interesting* or *more interesting.* The descriptive word *big* can be made into a scalar quantifier by adding the words *very* or *not very* to form *very big* or *not very big.* If you would like a review of this concept, look back at Chapter 6.

It is important to remember that more general terms are also used for quantities. These words, such as *some, almost never,* or *approximately,* have various shades of meaning. In reading and writing science one must be aware of these different meanings.

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TABLE 8-1 SCALE WORDS

	0%	10–20%	30–40%	50%	60–70%	80–90%	100%
Frequency words	never	rarely	seldom	some-times	often	almost always	always
Mass words	none	very little	not much	some	a lot of	a great deal	all
Counting words	none	very few	a few	a fair number	many, a lot of	a great many	all
Probability words	no chance	highly unlikely	some possi-bility	may	a good chance	almost certain	posi-tive, certain
Size words	infinitely small	very small	small	medium	big, large	very large	biggest, largest
Time words		very slow	slow	average (speed)	fast	very fast	the fastest

Two people can mean very different quantities when saying the same word. Just how many is *many?* How many are in a *few?* How often is *seldom?* How probable is *likely?* You might answer these questions very differently from the person sitting next to you. **Table 8-1** shows many kinds of scalar words including some general terms. You will recognize some of the words from Figures 7-3, 8-1, and 8-2.

Exercise 3 Scalar Words

The following sentences are taken from some of the reading passages in previous chapters. Use the words or forms from Table 8-1 or any other scalar words to complete the statements. The first item is done for you as an example.

a. There are a *large number of* galaxies in the universe.

b. Life __________________ exists elsewhere. Within our solar system, Europa, a tiny moon of Jupiter, is the place __________________ to support extraterrestrial life. In fact, conditions there would be __________________ hostile to life than the conditions that are thought to have existed in Earth's primordial oceans.

c. The end of the Ordovician period is marked by a ______________ change in the fossil records. A ______________ portion of all life-forms suddenly disappeared from Earth about 440 million years ago. This extinction was the first of five ______________ mass extinctions that have occurred during the history of life on Earth. Then, about 250 million years ago, the third and ______________ of all mass extinctions literally devastated our planet. At that time, ______________ 96 percent of all animals living at that time became extinct.

d. Plants produce oxygen. They also provide us with food; ______________ everything we eat comes from a plant or an animal that ate a plant. And plants provide us with ______________ ______________ useful products, such as wood, medicines, fibers for making cloth and paper, and rubber. Did you know that ______________ the food people eat actually comes from fruits?

Other Kinds of Quantifiers

There are other kinds of quantifying words that do not fit into the categories discussed early in this chapter. They can be called *nonscalars*. Nonscalars come in such a variety that they cannot easily be put into a few groups or categories. Although they are not as common as scalar words, they are still very important quantifiers. Most of the scalar words you have studied have been adjectives or descriptors. Nonscalars frequently are verbs that indicate some change in quantity. Words that suggest an approximate quantity can also be considered nonscalars because they do not fit strictly into a relative scale. **Table 8-2,** on the following page, gives some examples of nonscalar quantifiers.

TABLE 8-2 EXAMPLES OF NONSCALAR QUANTIFIERS

Type of word	Nonscalar quantifier	Example
Verbs that suggest a change in quantity or size	contract	When stars enter their third stage of life, they begin to contract.
	compress	We read how pressure compresses lignite, turning it into bituminous coal.
Words that indicate the normal state of things	usually	Overall, the distribution of the major biomes usually relates to climate and types of soil.
	typical	A typical flashlight has two batteries in it.
Words that suggest an approximate quantity	roughly	Over roughly 100 million years, small bodies came together to form planetesimals.
	about	The oldest continental rocks are about 4 billion years old.
	nearly	Adult amphibians eat nearly anything they can catch.

Exercise 4 **Finding the Quantifiers**

Read the following passage and list the quantifiers it contains. You may recall this passage from Chapter 2.

Cycles of the Universe

We saw earlier how our sun, moon, and planets came into being. But those events are only the first stage in the life of a star. The second stage is the one our solar system is in now. This second stage lasts as long as the star, in our case the sun, has enough energy, or enough hydrogen, to keep it burning.

When hydrogen begins to run out, the star enters the third stage. At first, the star contracts; then it swells to enormous size. Some stars become giants, while others become supergiants. Giants are 10 or more times bigger than the sun. Supergiants are at least 100 times bigger than the sun.

When its atomic energy is completely gone, a star enters its final stage of evolution. Gravity causes the star to collapse inward. What is left is a hot, dense core of matter called a white dwarf. White dwarfs shine for billions of years before they cool completely.

Some white dwarfs simply cool and die. During the process of cooling, others create one or more large explosions. A white dwarf that has such an explosion is called a nova. If the star was a supergiant, the white dwarf becomes a supernova after its huge explosion.

After exploding, some supernovas contract into a tiny, incredibly dense ball of neutrons, called a neutron star. A spoonful of matter from a neutron star would weigh 100 million tons on Earth. The remains of other massive stars contract with such a force that they crush their dense core and leave what astronomers think is a hole in space, or a black hole. The gravity of a black hole is so great that not even light can escape from it.

(from Modern Earth Science)

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CHAPTER 8 NUMBERS, WORDS, AND QUANTITIES

8-2 Calculating

Calculations are often written using the symbols for basic operations: +, −, ×, and ÷. But in speaking—and frequently in writing—words must replace these symbols. If you were asked to read 1 + 1 out loud, you would say, "one plus one" without even thinking about it. **Table 8-3** lists many ways to describe mathematical calculations. Then, Exercises 5 and 6 give you practice going back and forth between words and mathematical symbols.

TABLE 8-3 TERMS FOR MATHEMATICAL CALCULATIONS

Operation	Terms	Example
Multiplication	multiplied by	x multiplied by 5 equals 27.
	the product of	The product of 12 and 5 is 60.
	by multiplying	By multiplying the two numbers, you get 74.
	times	Twelve times 5 is 60.
	twice	Twice 12 is 24.
	of	Two-thirds of 60 is 40.
	square, squared	The square of 2 is 4.
	cubic, cubed	The box has a volume of 4 meters cubed.
Addition	sum, the sum of	The sum of 30 and 12 is 42.
	plus	Thirty plus 12 is 42.
	and	Ten and 5 is 15.
	(is) added to	Thirty added to 12 is 42.
Subtraction	minus	Five minus four equals one.
	subtracted (from)	Four subtracted from five equals one.
	less	Five less four equals one.
Division	divided by	Ten divided by 2 is 5.
	by dividing	A is determined by dividing y by z.
	over	Five over 2 is 2.5.
	percent	Thirty-three-and-a-third percent of 90 is 30.
	go into	Two goes into 10 five times.
Equals	is	Eight is 15 percent of x.
	equals	x equals y.
	is determined by	x is determined by adding a and b.
	the result	The result of $2y$ plus 5 is 12.

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Exercise 5 Changing Words into Numbers and Formulas

Change the following sentences to numbers and letters. The first item is done for you as an example.

a. Density (D) is defined as the amount of mass (m) in a volume (V) of one unit. In other words, the density of an object is determined by dividing its mass by its volume.

$D = \frac{m}{V}$

b. The result of $4x$ over 3 is 25.

____

c. Three multiplied by x is y^2.

____

d. The product of 3 and x equals 40.

____

e. x raised to the third power added to 5 is 69.

____

f. Twelve over 4 multiplied by x results in 27.

____

g. Six multiplied by x is 20 plus $2y$.

____

h. x added to y is equal to z over 20.

____

i. The product of y and z is 32.

____

j. The value of x is determined by multiplying y by the quantity x minus 2.

____

k. The sum of x and y is the same as y to the second power.

____

l. Twice x divided by y is subtracted from z.

____

m. Twice the difference of x subtracted from y is equal to 75.

____

n. Eight is 15 percent of x.

____

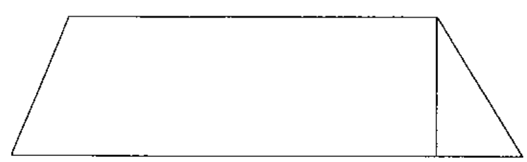
o. x is determined by dividing $12k$ minus 3 by $4r$.

____

p. x to the third power added to 15 percent of y equals 100.

____

q. An area (A) of a trapezoid of bases b_1 and b_2 and height h is one half the height times the sum of b_1 and b_2.



____

Exercise 6 Changing Numbers and Formulas into Words

Now try it the other way around. Write out these symbols and formulas as words. The first item is done for you as an example. Note that some of the answers will not be complete sentences.

a. $a = \pi \times r^2$

The area of a circle equals the number pi times the radius squared.

____

b. $4(\sqrt{x}) - y^2$

____

____

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Section 8-2 Calculating, continued

c. $w = \frac{a}{a^2} + b^2 - \frac{b}{a^2} + b^2m$

d. $2(x + 6)$

e. $(x^2 + 7)(y + 3)$

f. $9x^2 + 3 = 39$

g. $6\frac{x}{3}$

h. $z = \frac{11x + y^2}{3}$

i. $3x + 8 = \frac{28}{2}$

j. $\frac{5}{3}(x^2 + 2)$

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Describe Your Thinking

Scientists cannot just report a problem and suggest a solution to that problem. Good scientific reporting involves a description of how the problem was solved. This step is very important because part of making scientific discoveries is to have your findings confirmed by other scientists. To do this, one scientist must be able to read another scientist's report, follow their exact procedure, and get the same results. If other scientists do not know the correct process, they cannot confirm the findings.

When solving quantitative problems, you must describe your process using a combination of numbers and words. Exercise 6 gave you some practice describing how to solve problems. In that exercise, you were asked to convert mathematical symbols into words. By doing so, you described how to solve the mathematical expressions. In science, you will often need to describe mathematical solutions. But you will also often need to describe the solutions to nonmathematical scientific problems. Exercise 7 gives you practice describing how you arrived at particular solutions.

Exercise 7 How Did You Solve It?

While you are solving the following problems, write down the steps in your thinking. Include *all* the steps. The first item is done for you as an example.

a. If the word *sentence* contains less than nine letters and more than three vowels, circle the first vowel. Otherwise, circle the consonant that is farthest to the right in the word.

s e n t e n (c) e

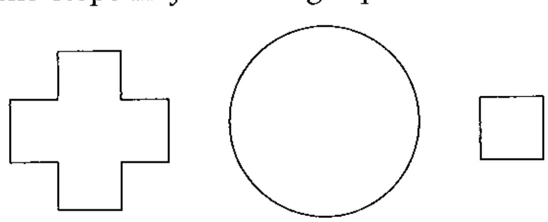
The word sentence contains eight letters. Yes, it is less than nine.

There are just three vowels, not more than three. So one of the

conditions is not met. Therefore, do not circle the first vowel.

Instead, circle the consonant farthest to the right, which is c.

b. If the circle below is taller than the square and the cross is shorter than the square, put a *K* in the circle. However, if these conditions are not true, put a *T* in the second-tallest figure. List the steps in your thought process on the next page.



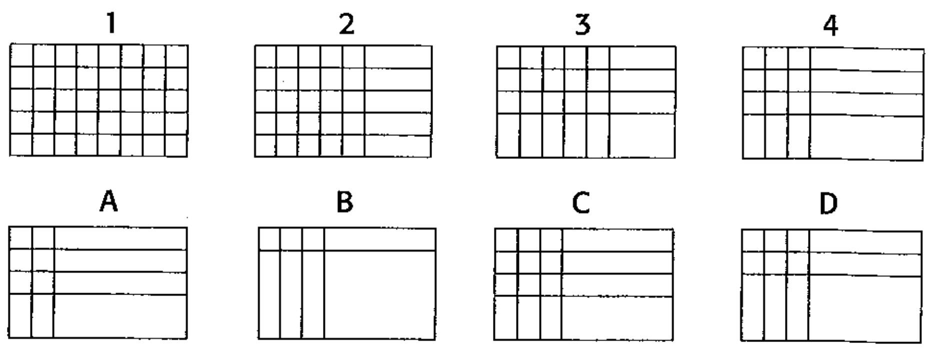
c. Tomorrow is Sunday. What day is two days after three days before yesterday?

d. Decide which three numbers should come next in this series, and write a description of the pattern. Then fill in the last three numbers.

2 7 4 9 6 11 8 13 ____ ____ ____

Section 8-2 Calculating, continued

e. The top four figures (1, 2, 3, and 4) have a pattern. This pattern changes in a regular (systematic) way. Try to discover the pattern and choose which item in the second group (A, B, C, or D) should occur next in the series



Exercise 8 What Kind of Information Is Needed?

There is not enough information to solve these problems. What information do you need? Write out your answers. The first item is done for you as an example.

a. A car can travel 30 miles on a gallon of gas. How far can it go on a tank of gas?

How much gas does the tank hold?

b. A bushel of apples weighs 100 pounds. If three bushels of apples weigh 300 pounds, how many apples are in three bushels?

c. Uranus has about 63 times the volume of Earth and is nearly 15 times as massive. What is the mass of Uranus?

d. Yard waste makes up nearly 1/5 of a community's municipal solid waste. Because it is biodegradable, yard waste can be allowed to decompose in a compost pile. If all yard waste became compost, how much compost would an average community produce?

e. A molecule of ammonia contains nitrogen and hydrogen. It has a mass of 17 atomic mass units. What is the mass of hydrogen in a molecule of ammonia?

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CHAPTER

8 NUMBERS, WORDS, AND QUANTITIES

8-3 Notation

You have probably seen coaches drawing diagrams of game strategies using *X*s and *O*s to represent players and lines to show where the players will run. This is a form of notation. **Notation** is any system of symbols. Notation can be used for scientific concepts and analysis. Notation is also used in music, dance, and games such as chess and football.

Remember how you analyzed the passages in Chapter 5 on cause and effect? You used forward and reverse arrows to show the direction of the cause and effect patterns in the sentences. These arrows are an example of notation used in a scientific analysis. **Figure 8-3** shows a common system of notation that you may find in your science textbook. Imagine how long it would take to read the instructions for an experiment if all of the safety information were written in complete sentences. The safety symbols in Figure 8-3 allow you to get the important safety information quickly.

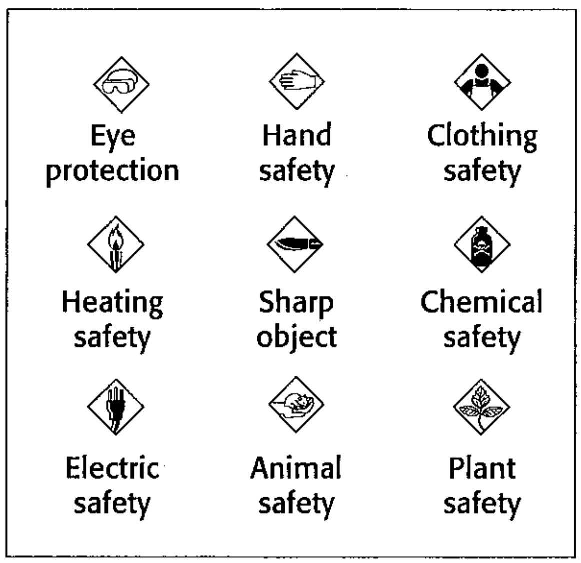


FIGURE 8-3 Safety symbols are used to indicate the hazards in a particular scientific experiment.

Basically, there are three kinds of marks used in notation: numbers, Greek and Roman letters, and various other symbols such as ∞, $\angle$, $\geq$, $^\circ$, $\pm$, or those found in Figure 8-3. Many of these symbols should be familiar from your math classes. There is a great deal of overlap between the symbols and letters used in math and in science. Exercise 9 will give you practice dealing with notation in scientific studies.

Exercise 9 Notation in Science

In each of the following items, a notation is given. Write out an explanation for the notation.

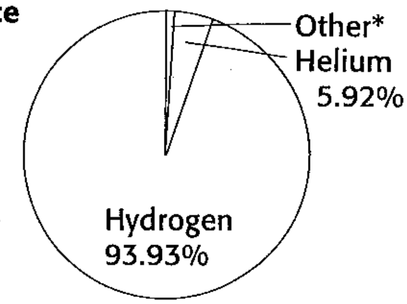
a. the mass of Uranus > the mass of Earth

____

____

b. Charts and graphs can also be used as notation to represent information in science.

Elemental abundance in universe



*Oxygen 0.075%, carbon 0.047%, nitrogen 0.0094%, neon 0.0087%, magnesium 0.0042%, silicon 0.0030%, other 0.0027%

____

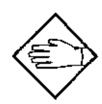
____

____

c.


Eye protection


Clothing safety


Hand safety


Chemical safety

____

____

d. DNA, deoxyribonucleic acid, contains four nucleic acid bases: adenine (A), guanine (G), thymine (T), and uracil (U). Write out an explanation for the following notation that describes a section of a DNA strand.

AATGUTG

____

____

Special Uses for Letters

The Roman alphabet is used for many types of scientific notation. If you want to find an example of a notation system in science that uses the Roman alphabet, all you need to do is look at the periodic table of the elements. The letter "H" stands for hydrogen. The letters "Fe" stand for iron. And the letters "Au" stand for gold. Another example can be found in the abbreviations for units, such as the letter "m" for meter, the letters "kg" for kilogram, and the letter "V" for volt.

Greek letters are also very common in science and engineering notation. You are probably already familiar with the letter pi, π. This letter is the factor used to find the area and circumference of a circle. Pi equals approximately 3.14159. The lowercase letters alpha (α), beta (β), and gamma (γ) are used as names for types of radiation. The letter beta is also used in the symbol β^+, which stands for the subatomic particle, the positron. The letter delta, Δ, generally symbolizes change. For example, a change in mass could be symbolized by the expression Δm. **Table 8-4** gives a list of the Greek letters that are commonly used in science. Can you think of any other Greek letters that are used for notation?

TABLE 8-4 THE GREEK ALPHABET USED IN SCIENCE

Name of letter	Upper case	Lower case
Alpha	A	α
Beta	B	β
Gamma	Γ	γ
Delta	Δ	δ
Pi	Π	π
Omega	Ω	ω

Uppercase (capitals) and lowercase (small) letters, in both the Greek and Roman alphabets may have very different meanings. For example, "G" is used as the abbreviation for gauss (a unit of electrical energy), while "g" is the abbreviation for the mass unit gram. The symbol t stands for temperature in degrees Celsius, and the symbol T stands for temperature in kelvins.

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The use of regular or italicized type has meaning too. An italicized letter usually denotes a symbol. Most abbreviations are shown as regular type. The same letter in the same case may have different meanings depending whether the letter represents a symbol or an abbreviation. While *T* is the symbol for temperature in kelvins, "T" also represents the abbreviation for tesla which is an electrical unit. The lowercase letter "g" is the abbreviation for the mass unit gram, but *g* is the symbol for the acceleration due to gravity. You can derive the correct meaning from reading the words around the notation.

Acronyms are a special kind of abbreviation. They are usually formed from the first letters of a name. They are usually written using only capital letters. **Table 8-5** lists some common acronyms and their meanings. Can you think of any other common acronyms?

TABLE 8-5 COMMON ACRONYMS

	Acronym	Meaning
Government agencies and programs	FBI	Federal Bureau of Investigation
	CIA	Central Intelligence Agency
	NASA	National Aeronautics and Space Administration
	EPA	Environmental Protection Agency
Special systems or scientific concepts	CPR	cardiopulmonary resuscitation
	AIDS	acquired immune deficiency syndrome
	DNA	deoxyribonucleic acid
Private companies	GE	General Electric
	GNC	General Nutrition Centers
	IBM	International Business Machines
Nonprofit organizations	AFL	American Federation of Labor
	NOW	National Organization for Women
	MDA	Muscular Dystrophy Association
	WTO	World Trade Organization
Technical societies	ACS	American Chemical Society
	NSTA	National Science Teachers Association
	AMA	American Medical Association

Exercise 10 Special Letters

Give a meaning for each of the following letters that are used as notation in science. Some are simple abbreviations, some are symbols, and some are acronyms. You may need to do a little research to find the answers.

a. RNA

____

b. W

____

c. mL

____

d. Ar

____

e. μm

____

f. O^+

____

g. λ

____

GLOSSARY

acronym a special kind of abbreviation that is usually formed from the first letters of a name (149)

notation a system of symbols used to represent something (146)

quantifier a word or phrase that indicates a quantity (131)

quantifying sense general feeling about the size, greatness, or amount of something (131)

scalar words quantifiers that can fit on a scale from 0% to 100%; terms that are a matter of degree (133)