chapter 1

Classifying

The Composition of Matter

INTRODUCTION

The early stages of scientific research involve making observations and gathering information. However, merely collecting facts is not enough. The scientist needs to arrange and classify the facts and to find relationships among them.

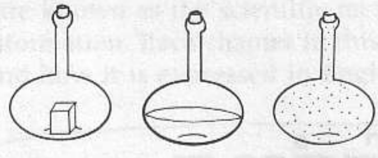
The word *classification* comes from the word *class*—meaning a group of things that all have one important element in common. Scientists group related information into an array. Chemists, for example, cannot study every element, but can make generalizations by arranging all the elements into groups with related properties. Thus, if iodine is identified as belonging to the same group as chlorine and bromine, its properties can be predicted. Similarly, since there are several million kinds of plants and animals on earth, it is clearly impossible to study each one. However, by classifying an animal as a member of a particular group, or species, a biologist can predict its characteristics. Classification is thus very basic to scientific thought and expression.

Short Reading

Read the following passage and find out how matter may be classified.

The Nature of Matter

Everything around us consists of matter: this book, your body, the air you breathe, and the water you drink. Matter is anything that has weight or mass and takes up space.



All matter may be classified as either solid, liquid, or gas. Solids are firm and have a definite form. Rubber, wood, glass, iron, cotton, and sand are all classified as solids. A considerable force would be needed to change the shape or volume of an iron bar, for example, because the atoms or molecules of a solid are densely packed and have very little freedom of movement.

Solids may be further divided into two classes: crystalline and amorphous. Rocks, wood, paper, and cotton are crystalline solids. Crystalline solids are made up of atoms arranged in a definite pattern. When these solids are heated, the change to a liquid, known as melting, is sharp and clear. Amorphous substances include rubber, glass, and sulfur. In these substances, the pattern of the atoms is not orderly, and when heated, they gradually soften.

Liquids, on the other hand, are not rigid. If water, milk, or oil is poured on a table, it will flow all over the surface. The atoms or molecules of liquids attract each other and thereby enable liquids to flow. But these atoms are loosely structured and do not keep their shape. Therefore a liquid will take the shape of any container in which it is poured. However, liquids have a definite volume; a quart of milk cannot fit in a pint container.

Gases, such as air, oxygen, and carbon dioxide, have no fixed shape or volume of their own. They diffuse or spread out to fill any container. If water is put into a tire, it will run to the bottom; if air is put into a tire, it fills the whole space inside the tire. The atoms or molecules of gases are widely spaced and move very rapidly. They either compress or expand to adapt to any area.

Everything we know is made of matter in solid, liquid or gaseous form. Later in this chapter, we will discuss other ways matter may be classified.

USING ENGLISH TO CLASSIFY

A classification includes:

1. a general class,
2. a specific item or items, and
3. a basis for classification, which is frequently *not* stated because it is understood or explained elsewhere.

Consider this sample sentence:

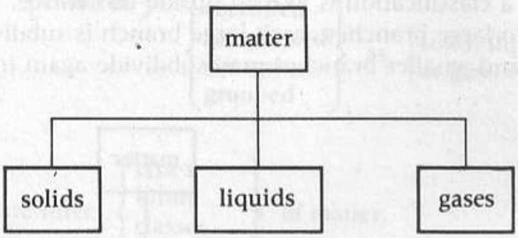
All matter may be classified as either solid, liquid, or gas.

The general class is *matter*. The specific items are *solid, liquid,* and *gas*. The basis for classification is the physical state of matter, which is not mentioned in the sentence.

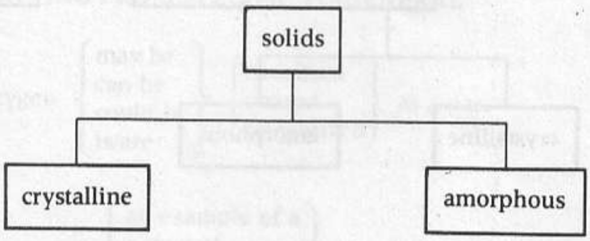
But there is more than one way matter may be classified. For example, it may be classified on the basis of its chemical composition as either living or nonliving. For this reason, classification sentences frequently contain modals of possibility, such as *can, could,* or *may*.

CLASSIFYING FROM GENERAL TO SPECIFIC

All matter may be classified as either solid, liquid, or gas.
(Note that all matter is included in these three subdivisions.)

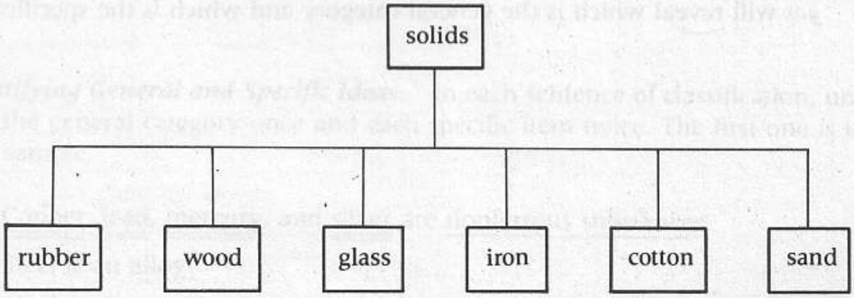


Solids may be further divided into two classes: crystalline and amorphous.

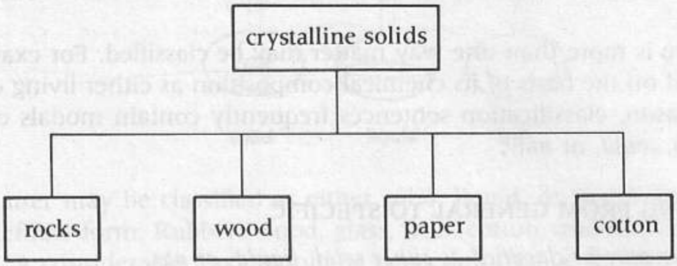


CLASSIFYING FROM SPECIFIC TO GENERAL

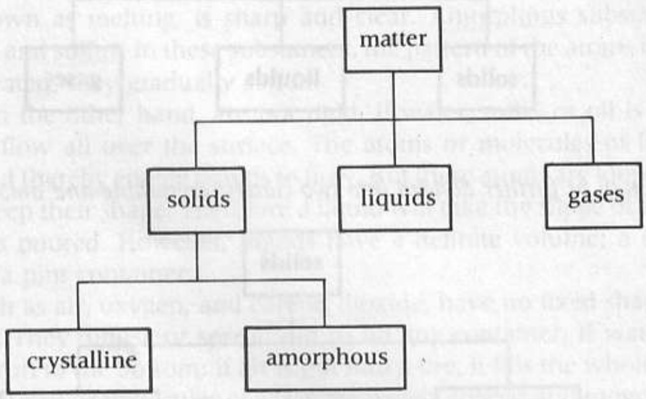
Rubber, wood, glass, iron, cotton, and sand are all classified as solids.
(When classifying from specific to general, the specific items do not necessarily cover all the subdivisions of the general category; that is, there are obviously other solids that are not included here.)



Rocks, wood, paper, and cotton are crystalline solids.



(Note that a classification is like an upside-down tree. The trunk of a tree is divided into large branches, each large branch is subdivided into smaller branches, and smaller branches may subdivide again into even smaller branches.)



NOTES

1. The passive form is used frequently in sentences of classification and in all scientific writing because the emphasis in science is usually on the action, not on the person performing the action.
2. The present simple tense is the most commonly used tense in scientific writing because it expresses universals. (For example, *Water freezes at 0° C.*)
3. In a sentence like, *Oxygen is a gas*, only the meanings of the words *oxygen* and *gas* will reveal which is the general category and which is the specific item.

Sentence Patterns

CLASSIFYING FROM GENERAL TO SPECIFIC

Matter	is/are may be can be could be	classified grouped divided arranged categorized	into	divisions. groups. types. classes. categories. classifications.
		classified categorized classed grouped	as	solid, liquid, or gas.

There are three	types kinds classes categories	of matter.

CLASSIFYING FROM SPECIFIC TO GENERAL

Oxygen	may be can be could be is/are	classified classed categorized	as a gas.

Oxygen is	an example of a a type of a kind of a form of a	gas.

Note: These sentence patterns are only samples, not *a comprehensive list of all possible patterns.*

Identifying General and Specific Ideas. In each sentence of classification, underline the general category once and each specific item twice. The first one is done as a sample.

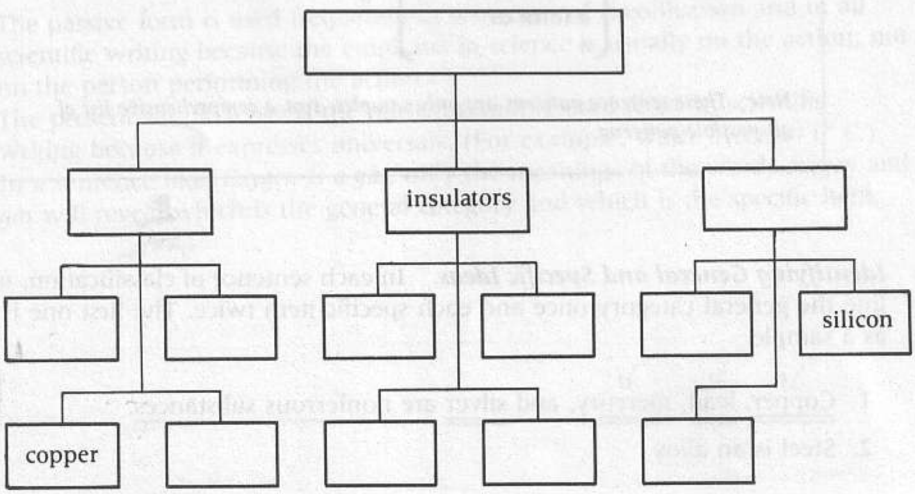
1. Copper, lead, mercury, and silver are nonferrous substances.
2. Steel is an alloy.

3. Five important classes of compounds are acids, bases, salts, metallic oxides, and nonmetallic oxides.
4. A deer is a mammal.
5. Carbon exists in three forms: graphite, diamond, and amorphous.
6. Rocks are grouped into three categories: igneous, metamorphic, and sedimentary.
7. Coffee, tea, and paint are colloids.
8. Coal, wood, and oil may be classified as fuels.
9. Salts are inorganic compounds.
10. The two kinds of nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).

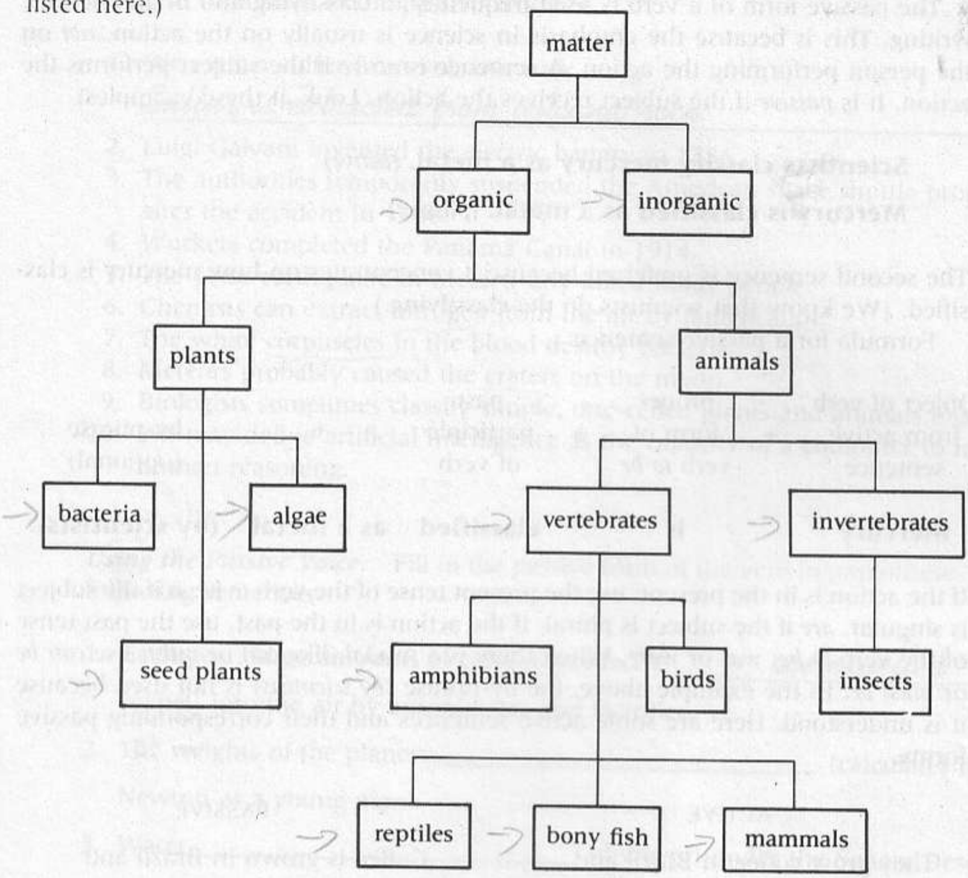
Transferring Information. Read the following paragraph and find another way that matter may be classified. Then use the information in the passage to complete the chart.

ELECTRICAL CONDUCTIVITY

Matter is frequently classified according to its electrical conductivity as a conductor, nonconductor, or semiconductor. Conductors have many electrons that are free to move and are useful in carrying, or conducting, electric current. All metals, particularly silver, copper, gold, and aluminum, are good conductors. Substances with few free electrons are called nonconductors, or insulators, because they do not carry electric charge and can be used to prevent electricity from flowing where it is not wanted. Air, wood, glass, and plastic are insulators. A few substances, like carbon, silicon, and germanium, do not fall into either of these categories. They are classed as semiconductors and are used in such electronic devices as transistor radios.



Completing Sentences. Complete the following sentences. Use the sentence patterns on p. 7 to help you. (Note that not all categories of plants and animals are listed here.)



1. There are two ___categories___ of animals: vertebrates and invertebrates.
2. Organic matter can be ______________ into two ______________: plants and animals.
3. Algae are a ______________ of plant.
4. Insects can be ______________ as invertebrates.
5. Matter may be ______________ into two ______________: organic and inorganic.
6. Reptiles and amphibians are ______________ as vertebrates.
7. Bacteria can be ______________ as plants.
8. Invertebrates are a ______________ of animal.

The Passive Voice

The passive form of a verb is used frequently in classifying and in all scientific writing. This is because the emphasis in science is usually on the action, *not* on the person performing the action. A sentence is *active* if the subject performs the action. It is *passive* if the subject receives the action. Look at these examples:

Scientists classify mercury as a metal. *(active)*

Mercury is classified as a metal. *(passive)*

The second sentence is preferred because it concentrates on how mercury is classified. (We know that scientists do the classifying.)

Formula for a passive sentence:

Object of verb from active sentence	+	proper form of verb *to be*	+	past participle of verb	+		by-phrase (optional)
Mercury		**is**		**classified**		**as a metal**	**(by scientists).**

If the action is in the present, use the present tense of the verb *to be*: *is* if the subject is singular, *are* if the subject is plural. If the action is in the past, use the past tense of the verb *to be*: *was* or *were*. When there is a modal, like *can* or *must*, use *can be* or *must be*. In the example above, the by-phrase (*by scientists*) is not used because it is understood. Here are some active sentences and their corresponding passive forms.

ACTIVE	PASSIVE
They grow coffee in Brazil and Columbia.	Coffee is grown in Brazil and Columbia.
We use lasers in place of needles in compact disc recordings.	Lasers are used in place of needles in compact disc recordings.
They discovered diamonds in South Africa in the nineteenth century.	Diamonds were discovered in South Africa in the nineteenth century.
James Watson and Francis Crick formulated the theory of the double helix.	The theory of the double helix was formulated by James Watson and Francis Crick.
Penicillin can cure pneumonia.	Pneumonia can be cured by penicillin.

Changing Active Voice to Passive Voice. Change each of the following active sentences to the passive form. Be careful to choose the correct tense (present or past) and the correct number (singular or plural) for the verb *to be*. Include a by-phrase when you think the original subject (that is, the subject of the active sentence) is important to the passive sentence.

1. We extract sulfur from volcanic rock.
   Sulfur is extracted from volcanic rock.
2. Luigi Galvani invented the electric battery in 1786.
3. The authorities temporarily suspended the American space shuttle program after the accident in 1986.
4. Workers completed the Panama Canal in 1914.
5. The 1986 earthquake in Mexico City killed many people.
6. Chemists can extract nitrogen from the air by liquefication.
7. The white corpuscles in the blood destroy bacteria.
8. Meteors probably caused the craters on the moon.
9. Biologists sometimes classify simple, one-celled plants and animals together.
10. We may define artificial intelligence as the capacity of a computer to imitate human reasoning.

Using the Passive Voice. Fill in the passive form of the verb in parentheses in the following sentences.

1. Each year, large amounts of carbon monoxide ___are expelled___ (expel) into the air by automobiles and factories.
2. The weights of the planets ______________ (calculate) by Newton as a young man.
3. Water ______________ (discover) under the Sahara Desert.
4. Coal ______________ (produce) by plant matter of prehistoric times.
5. Soap ______________ (manufacture) by boiling vegetable or animal fat with sodium or potassium hydroxide.
6. The hydrogen bomb ______________ (call) a thermonuclear bomb because extremely high temperatures ______________ (need) to start the fusion process.
7. Human speech ______________ (control) by a part of the brain called the cerebrum.
8. The concept of relativity ______________ (propose) by Albert Einstein in 1905.

READING SKILLS

Vocabulary Building

A good vocabulary will help you with every aspect of communication; it will improve your reading and listening comprehension and will enable you to speak and write better. A good vocabulary will help you succeed in any profession.

When you first study a language, you learn everyday words that are repeated so often that they soon become part of your permanent vocabulary. However, after you have acquired a basic vocabulary, there is always a decline in vocabulary growth rate. Reading and speaking the language will increase your fluency but will *not* automatically increase your vocabulary. This is because the words you are learning appear less frequently and are thus more difficult to remember. At this stage of language development, you must make a special effort to acquire new words.

All the words in the vocabulary sections in this book were selected from the readings and lectures because they appear frequently in scientific discourse. There are no rare or specialized words. The word parts are also those found frequently in scientific terminology. In addition, the vocabulary sections contain strategies for continuing to build your vocabulary, that is, for making vocabulary growth a lifetime habit.

Vocabulary in Context. Circle the letter of the answer that best matches the meaning of the italicized word as it is used in each of these sentences.

1. Atoms are *infinitesimal* in size.
   a. tiny b. huge
2. Chemists study the composition of natural *substances.*
   a. materials b. machines
3. The whale suddenly *emerged* from the water.
   a. arose b. disappeared
4. All matter is either liquid, solid, or gas, and solids may be *subdivided* into crystalline and amorphous.
   a. built up b. broken down
5. Plastic products are hard to dispose of because they are almost *indestructible.*
   a. unable to be destroyed b. unable to be constructed
6. At one time the atom was thought to be *indivisible.*
   a. unable to be divided b. unable to be seen
7. Einstein's ideas are too *abstract* for many people to understand.
   a. practical b. theoretical

8. The *reaction* of iron and oxygen produces rust.
   a. chemical activity b. separation
9. The airplane had to rely on radar in the *dense* fog.
   a. thick b. thin
10. The moon *revolves* around the earth.
   a. stretches b. circles
11. The mosquitoes showed their *attraction to* the light.
   a. dislike for b. liking for
12. Some scientists suspect that the planet Uranus once *collided* with another object in space.
   a. crashed b. orbited

Finding Main Ideas

Scientific writing consists mainly of concepts and material that supports those concepts. The concept is usually stated in a *topic sentence*, which acts as an umbrella to cover all the information in the paragraph. The rest of the paragraph contains supporting material—that is, information that explains, clarifies, or proves what is stated in the topic sentence.

The topic sentence is frequently but not always the first sentence of the paragraph. Sometimes it is the second sentence, appearing after an introduction or transition. At other times it is the last sentence, with other sentences leading up to it. Only rarely does it appear in the middle of the paragraph. All the sentences in the paragraph should relate to the topic sentence. (Occasionally a paragraph has no topic sentence because it contains support material for an earlier paragraph or acts as a transition between other paragraphs.)

In the following passage, put square brackets [] around the topic sentence of each paragraph.

Reading

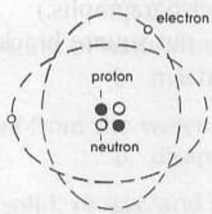
The Infinitesimal Atom

There are over four million substances known to man. [Yet it is one of the amazing facts of science that all these substances are made up of only about 100 different varieties of matter, which are called elements.] Oxygen, hydrogen, gold, aluminum, sulfur, carbon, and chlorine are all examples of elements that combine in different ways to make the more than four million substances. Elements are made of particles called molecules, too tiny to be seen even with a powerful microscope. Molecules are made of even smaller particles called atoms. All the world is made of atoms.

The concept of atoms first emerged in ancient Greece. In 400 B.C. the philosopher Democritus theorized that matter could be divided into smaller and smaller particles until a point was reached beyond which no further subdivision was possible. These indestructible particles were called *atomos*, a Greek word meaning indivisible. We know today that atoms are so small that it would take more than a million of them to equal the thickness of this sheet of paper. Democritus' theory, however, was not universally accepted in the ancient world, for many believed in Aristotle's theory that matter is composed of four elements: earth, fire, air, and water.

During the Middle Ages in Europe, the concept of atoms was considered too abstract and was accordingly rejected. Finally, in 1804 the Englishman John Dalton formulated an atomic theory based on his experimentation. He claimed that all matter is made of atoms; that all atoms of a single element have the same shape, size, weight, and behavior; and that atoms of each element are different from those of any other element. He said that atoms are not created or destroyed but rather form new combinations in chemical reactions.

Dalton thought that atoms were solid, but today atoms are believed to consist mainly of space, with a dense nucleus at the center. The size of the nucleus inside an atom is comparable to the size of an ant on a football field. Each nucleus contains protons, which have a positive electric charge, and neutrons, which have no charge. The nucleus is surrounded by electrons, which have a negative electric charge. The number of protons equals the number of electrons in each atom, and therefore the entire atom has no charge. In 1913, the Danish physicist Niels Bohr proposed a model of the atom in which the electrons revolved around the nucleus like the planets revolve around the sun. Today the movement of electrons is thought to be more like bees hovering around a hive. The force of attraction between the positive protons in the nucleus and the negative electrons whirling around keeps the electrons in their paths.



helium atom

What is it that makes iron hard, oxygen a gas, and mercury a liquid? The properties of an element are determined by the number of electrons in an atom, which is called the atomic number. All atoms of the same element are alike. If you've seen one atom of oxygen, you've seen them all. Hydrogen, the lightest element, has one electron and one proton. In fact, the hydrogen atom, the most common atom in the universe, is the basis on which our entire universe was formed. Oxygen has eight protons and eight electrons. Uranium, one of the heaviest elements, has 92 protons and 92 electrons.

All the world is made of atoms: Everything we see and know of is made of the billions and billions of these infinitesimal specks of matter. All life exists because atoms are continually moving, combining, separating, colliding, giving off energy, and absorbing energy.

Understanding the Reading. Each of the following statements is inconsistent with the information in the previous passage. Test your reading comprehension by finding and correcting each error.

1. Molecules are even smaller than atoms.
   Atoms are even smaller than molecules.
2. The concept of the atom did not exist before 1804.
3. In ancient Greece, everyone believed Aristotle's theory that matter is composed of four elements: earth, fire, air, and water.
4. During the Middle Ages, the atomic theory was widely accepted.
5. John Dalton theorized that atoms are composed of electrons, protons, and neutrons.
6. The size of a nucleus inside an atom is equal to the size of an ant.
7. Atoms are densely packed with protons, neutrons, and electrons.
8. Neutrons have a negative electric charge.
9. Each atom is neutral because the number of its protons equals the number of its neutrons.
10. Niels Bohr proposed a model of the atom with the electrons revolving around the planets.
11. Electrons are kept in their paths by the force of gravity.
12. The atomic number of an element is the total of the number of electrons and the number of protons.
13. All the atoms of a single element are different.
14. Atoms of hydrogen are identical to atoms of oxygen.
15. The oxygen atom is the most common atom in the universe.

LISTENING SKILLS

Vocabulary in Context. Circle the letter of the answer that best matches the meaning of the italicized word as it is used in each of these sentences.

1. Water *decomposes* into hydrogen and oxygen.
   a. separates b. evaporates
2. Diamonds are expensive partly because they are so *rare*.
   a. scarce b. abundant

3. The device was driven by *mechanical* energy.
   a. machine b. electrical
4. Although hydrogen and oxygen have some similarities, each has characteristics that are *distinct*.
   a. similar b. different
5. Sodium and chlorine are the *constituents* of salt.
   a. components b. characteristics
6. Oxygen is a very *active* element that combines readily with other elements.
   a. stable b. unstable
7. Some mushrooms are safe to eat, and others are *poisonous*.
   a. delicious b. deadly
8. It was important to keep the temperature *constant* throughout the experiment.
   a. unchanging b. changing
9. The outcome of an experiment is affected by *variables*.
   a. substances b. changing factors
10. Besides nitrogen and oxygen, there is a small *proportion* of other gases in the air.
    a. quality b. quantity
11. The noble gases are a group of gases with *homogeneous* properties.
    a. similar b. different
12. A mosquito is *categorized* as an insect.
    a. classified b. described
13. A flower can only *retain* its beauty for a short time.
    a. keep b. lose

Note-Taking

Many people like to take a camera when they make a trip partly because they know that they will remember the people and places they have recorded on film and forget much of the rest. The notes you take during a lecture are like the photographs you take on a trip. What you record, you will retain; most of the rest, you will forget. Without notes, in a short while you will undoubtedly forget most of the material presented in a lecture, even when the subject matter is interesting to you. Just as with pictures, your goal is to record as many important points as clearly and specifically as possible. Note-taking will *not* interfere with your listening. On the contrary, it will help you to focus on what is being said and avoid letting your mind wander. The succeeding chapters contain suggestions for good note-taking.

Take notes as you listen to the lecture "The Chemistry of Matter," and then use your notes to complete the next exercise.

Using Your Notes to Classify. Use the information from the lecture to classify each of these statements as describing an element (*E*), mixture (*M*), or compound (*C*).

__M__ 1. Its constituents may be present in any proportion.

____ 2. Its constituents cannot be separated by mechanical means.

____ 3. Alcohol is an example of one.

____ 4. It cannot be broken down into simpler substances by ordinary chemical means.

____ 5. There is more than one type of atom within each molecule.

____ 6. It retains the properties of its constituents.

____ 7. Milk is an example of one.

____ 8. Carbon is an example of one.

____ 9. The law of definite composition applies.

____ 10. There are only about 92 found in nature.

____ 11. Its characteristics are different from those of its constituents.

____ 12. They are frequently categorized as metals and nonmetals.

DISCUSSION POINTS

1. How might you classify the students in this class or school?
2. What are some ways you could classify foods? fabrics? cars? schools? films? cities? academic subjects? animals? jobs? the people of a town or country? music?
3. A nutritionist might be interested in classifying foods according to calories, sodium content, cholesterol content, sugar content, vitamin content, and the like. This information would be needed to prescribe a diet for a specific person. What types of classification might interest a biologist? a chemist? a meteorologist? a psychologist? a police detective? a football player?

WRITING SKILLS

Topic Sentences

In English, written material is organized into paragraphs. Each paragraph expresses a complete thought. This central thought or idea is summarized in the topic sentence, which should cover everything that is in the paragraph and *only* what is in the paragraph.

The topic sentence may appear at the beginning of the paragraph to announce the main idea. Or it may appear at the end to summarize that idea. The topic sentence unifies the paragraph and makes it clear and understandable to the reader. The rest of the sentences in the paragraph should give details that support, explain, or prove the main point.

The sample paragraph below is incomplete. Read it and think of a good topic sentence to unify it. Also, find the one sentence that does *not* belong in the paragraph.

Astronomers classify planets according to their positions in relation to the earth. Those that are inside the earth's orbit (that is, Mercury and Venus) are classed as inferior planets. All the others are called superior planets. Recent space explorations have uncovered no evidence of life on any of these planets. Planets may also be classified according to their size and mass. Mercury, Venus, Mars, and Pluto are sometimes called the terrestrial planets because they are similar in size to the earth. Jupiter, Saturn, Uranus, and Neptune are the major or larger planets. Jupiter is the largest, followed by Saturn and then the "twins," Uranus and Neptune.

Which of the following is the best topic sentence for this paragraph?

1. Planets may be classified according to size and mass.
2. Planets may be classified according to position or size.
3. Scientists classify many things in the universe.
4. Planets may be classified according to position.

Sentences 1 and 4 are too narrow to be the topic sentence, for neither covers all the information in the paragraph. Sentence 3 is not the best because it is too broad; it is not specific to this paragraph. Sentence 2 is the best topic sentence because it announces exactly what the paragraph is about—no more, no less.

Which sentence does not belong in the paragraph? The sentence that begins *Recent space explorations . . .* is *not* relevant to the topic of classification and therefore should not be included.

Writing a Paragraph of Classification

Write a paragraph of classification based on one of the Discussion Points that interests you. Start the paragraph with a topic sentence that

1. states the main idea,
2. is broad enough to cover everything in the paragraph, and
3. is specific enough to cover only what is in the paragraph.

The rest of the sentences should provide the details that relate to, support, or explain the topic sentence.

Always reread your paragraph, preferably after some time has passed. Check to see that every sentence is related to the topic sentence.

chapter 2

Comparing

The Elements

INTRODUCTION

Scientists try to organize information by seeking relationships. Classification is one way of arranging information. Comparing is another.

Comparisons not only arrange information but also expand it. When prehistoric human beings noticed that wood burns and stone does not, they were making an important step toward advancing scientific knowledge. Often comparisons enable us to solve problems. For example, to determine which substance to use for electrical wiring, various metals are compared for electrical conductivity, cost, availability, and the like.

Comparisons provide a new perspective on information. For example, the fact that an ant can carry a crumb of bread only becomes impressive when the crumb is discovered to be three times the weight of the ant. The fact that water expands when it becomes solid is more interesting when comparisons show that all other liquids contract, or take up less space, as they solidify. It was a comparison of the habits of lung cancer victims with those of the general population that led to the discovery of a link between smoking and lung cancer. Comparisons are thus a part of every aspect of science.

Short Reading

Read the following passage and find as many comparisons as you can.

The Wonder Metals

The study of metals began in the Middle Ages when alchemists searched for a technique to convert "base metals," like lead, to gold. They never succeeded in making gold but at least by experimenting with the metals (in contrast to the ancient Greeks, who only speculated about them) they made many discoveries.

All but 20 of the over 100 elements identified to date are metals but only 7 of these are common in the earth's crust. Iron, the most widely used metal, is rarely found in the free state (not combined with other metals) and must be extracted from naturally occurring compounds (ores) such as hematite, magnetite, and pyrite. The beautiful colors of rocks are due almost entirely to these iron compounds. In fact, iron pyrite is often called fool's gold because of the similarity of its color to gold. Iron is very strongly magnetic, and the fact that the earth is a magnet itself tipped scientists off to the fact that iron is a major component of the earth's core, or center.

Pure iron is a relatively soft, silvery metal that is very active chemically (that is, it combines with oxygen to corrode or form rust). It is usually mixed with other elements or compounds to form alloys such as steel, stainless steel, or cast iron, which are more durable and rust resistant than pure iron.

Aluminum is the most abundant metal, but it was not used until a century ago because it is so active chemically and difficult to extract. Like iron it is soft, but in contrast to iron and steel, aluminum is very light and more resistant to corrosion. These qualities make it useful for airplanes, trains, automobiles, rockets, and house siding.

In the 1940s, magnesium emerged as an important metal. Although it is less abundant in the earth, more chemically active, and harder to extract than aluminum, it is present in sea water and that means there is almost an endless supply of it.

In the space age, the extraordinary properties of titanium have made it the new wonder metal. Lighter and stronger than steel, it is more resistant to corrosion and able to withstand heat.

The remaining major metals are sodium, potassium, and calcium, all too active chemically (they react violently with water) for use in construction.

USING ENGLISH TO COMPARE

Comparing is examining two or more items to discover their similarities and differences. Comparing may but does not always concentrate on similarities. Contrasting concentrates on differences.

COMPARING SIMILARITIES

. . .iron pyrite is often called fool's gold because of the similarity of its color to gold.

color: iron pyrite ≈ gold

Like iron it [aluminum] is soft. . . .

softness: iron ≈ aluminum

CONTRASTING DIFFERENCES

Iron, the most widely used metal. . . .

use: iron > all other metals

Pure iron is a relatively soft, silvery metal. . . .

softness: iron > many other metals

Aluminum is the most abundant metal. . . .

abundance: aluminum > all other metals

. . .in contrast to iron and steel, aluminum is very light and more resistant to corrosion. . . .

lightness: aluminum > iron and steel
resistance to corrosion: aluminum > iron and steel

Although it [magnesium] is less abundant in the earth . . . than aluminum. . . .

abundance: magnesium < aluminum

Sentence Patterns

COMPARING SIMILARITIES

Magnesium is { like / similar to / comparable to / as important as } aluminum.

Magnesium { resembles / parallels } aluminum in many ways.

CONTRASTING DIFFERENCES

Iron { is unlike / is different from / differs from } aluminum.

{ Unlike iron, / In contrast to iron, / Compared to iron, / In comparison to iron, } aluminum is light.

Iron is { heavier than / less abundant than / not as soft as } aluminum.

Iron is a { relatively / comparatively } soft metal.

Understanding Comparisons. Read the passage below to determine the order of the seven italicized metals according to their melting points. List the metal with the *highest* melting point *first.*

The melting point of *platinum* is high compared to most metals but not as high as that of *chromium.* The melting point of *zinc* is less than half the melting point of *gold* and approximately three times the melting point of *sodium. Mercury* has the lowest melting point of all the metals. *Copper* and gold have similar melting points, but the melting point of copper is slightly higher than gold and lower than platinum.

Using a Table. Tables, charts, and graphs organize information to enable us to see comparisons readily. Circle the answer that best completes the statement according to the information in the chart.

The Physical Properties of Six Metals

Metal	*Specific Gravity*	*Melting Point (°C)*	*Boiling Point (°C)*	*Atomic Radius (Å)*	*Ionic Radius (Å)*
Group I					
Copper	8.9	1083	2595	1.17	.96
Silver	10.5	960	2212	1.34	1.26
Gold	19.3	1063	2966	1.34	1.37
Group II					
Zinc	7.14	420	907	1.25	.74
Cadmium	8.65	321	765	1.41	.96
Mercury	13.60	−38.87	357	1.44	1.1

1. The atomic radius of cadmium is ________ that of mercury.
   a. as high as   (b.) not as high as
2. ________ mercury, cadmium has a high boiling point.
   a. Like   b. Compared to
3. The specific gravity of cadmium and copper are ________.
   a. similar   b. identical
4. Compared to the other metals on this table, gold has ________ specific gravity.
   a. a relatively high   b. the highest
5. The properties of cadmium and zinc are ________.
   a. comparable   b. identical
6. Copper and gold have ________ high boiling points.
   a. comparatively   b. equally
7. The melting points of the Group II metals are ________ those of Group I.
   a. lower than   b. as low as
8. The ionic radius of copper is ________ to that of cadmium.
   a. similar   b. equal

Creating Sentences. Write a sentence comparing the items in each of these pairs. There is more than one way to write each answer.

1. surface temperature: Mercury—350°C
   Venus—475°C

   The surface temperature of Mercury is lower than that of Venus.

2. maximum life span: kangaroo—16 years
   cat—23 years
3. calories: apple (medium)—75
   egg—70
4. diameter: moon—3,480 km
   earth—12,800 km
5. gestation period: elephant—21 months
   giraffe—14–15 months
6. percent of world's water: Pacific Ocean—46%
   Atlantic Ocean—22.9%

Creating Comparisons. Compare the items in each of these pairs orally in one or two sentences. Note that the items have something in common, for otherwise there would be no point in comparing them. A good way to make a comparison is to begin with what they have in common. Include at least one way the items are similar and one way they are different. For example, to compare tea and coffee, you might say, "Both coffee and tea are drinks, but coffee is made from a bean and tea is prepared from leaves."

1. a telescope and a microscope
2. a submarine and a dolphin
3. a computer and a calculator
4. a desert and a jungle
5. a photocopier and an x-ray machine

Like *and* As

Comparisons frequently use the words *like* and *as*. *Like* is used before a noun or pronoun:

He thinks like a scientist.

But if the noun or pronoun is followed immediately by a verb, the word *as* is used:

Don't do as I do, do as I say.

As is also used before and after an adjective, like two slices of bread sandwiching in the adjective:

The night was *as* long *as* the day.
(The night and day were equally long.)

Silver is not *as* malleable *as* gold.
(Silver is less malleable than gold.)

Using **Like** *and* **As**. Fill in the blanks in each of the following sentences with *as* or *like*.

1. Sodium, ____like____ potassium, is an alkali metal.
2. The ancient Greek scientists did not experiment ____________ modern scientists do.
3. Modern computers are not ____________ large ____________ the first computers.
4. ____________ Galileo before him, Newton studied motion.
5. Cobalt is a heavy metal ____________ nickel.
6. Helium is almost ____________ light ____________ hydrogen.
7. Nickel does not rust ____________ iron does.

READING SKILLS

Vocabulary Building

Interrupting a reading or lecture to look up words in a dictionary will break your concentration. Therefore, when you read or hear a new word, you should always try to figure out its meaning from its context. Sometimes the sentence itself contains a definition:

Silver sulfide, a black chemical substance, forms on its surface.

At other times, the surrounding sentences or paragraph gives some indication of the meaning:

Gold is a ductile metal. One gram of gold can be drawn into a wire 1.8 miles in length.

From these two sentences, you can conclude that a ductile metal is one that can be stretched or pulled into wire.

In the vocabulary sections of each unit, you will have the chance to figure out word meanings from sentences. Then, in the readings and lectures, you can use other clues to help you understand the word.

Vocabulary in Context. Circle the letter of the answer that best matches the meaning of the italicized word as it is used in each of the following sentences.

1. Silicon is a nonmetallic element that is inexpensive because it is so *abundant* in minerals and rocks.
   a. rare b. plentiful
2. When exposed to air and moisture, iron will *corrode*.
   a. rust b. shine
3. When the flames subsided, the police investigated the cause of the *combustion*.
   a. burning b. excitement
4. The *spontaneous* explosion caused a lot of damage.
   a. unplanned b. planned
5. The room got stuffy and warm due to improper *ventilation*.
   a. heating b. air circulation
6. Many lives could be saved if natural *phenomena* such as earthquakes and hurricanes could be predicted.
   a. resources b. occurrences

7. There is oxygen in the *protoplasm* of all plants and animals.
   a. blood b. living matter
8. Amphibians are *organisms* that live on land and in water.
   a. minerals b. living things
9. Human *respiration* involves inhaling oxygen and exhaling carbon dioxide.
   a. breathing b. circulation
10. *Inhaling* smoke is bad for your lungs.
   a. breathing out b. breathing in
11. Larger vehicles *consume* more gasoline than smaller ones.
   a. use b. save
12. Water is *vital* to all living things.
   a. necessary b. useless
13. Heat can *convert* a solid to a liquid.
   a. condense b. change
14. Farmers *fertilize* their soil to make it more productive.
   a. enrich b. ruin
15. The ammonia was *diluted* in water to make it weaker.
   a. thinned b. thickened
16. A *catalyst* speeds up a chemical reaction.
   a. chemical agent b. forest animal
17. *Antibiotics* will cure many diseases but not the common cold.
   a. bacteria-killing drugs b. pain-killing drugs
18. Today, local *anesthetics* are being used in place of general anesthetics for many operations.
   a. painkillers b. stimulants
19. To obtain aluminum, metallurgists must *extract* it from bauxite.
   a. remove b. destroy
20. Gasoline should be stored carefully because it is *flammable*.
   a. fireproof b. able to catch fire easily

Skimming

When studying science, you will usually want to know if a reading passage contains the information that you need. In that case, it is advisable to skim the material *without* reading it all to get a general idea of its contents. To skim a passage:

1. Read the title and any subtitles, which are like little summaries.
2. Read the introduction.

3. Read the first sentence of every paragraph, which frequently, although not always, contains the main idea.
4. Read the summary or conclusion at the end of the passage.

Note: To skim a whole book, read the first paragraph and conclusion of each chapter.

Skim the following passage to discover its main topic and the information it contains. Then answer the following questions. Try to do this all in three and a half minutes. (You will be given time to read the passage thoroughly later.)

1. The main topic of this reading is:
   a. the industrial uses of oxygen, nitrogen, and hydrogen.
   b. how oxygen, nitrogen, and hydrogen differ from the other elements.
   c. the importance of oxygen, nitrogen, and hydrogen to living things.
   d. the differences between the three gases.
2. All of the following topics are discussed in the passage *except*:
   a. oxidation.
   b. a comparison of nitrogen and oxygen.
   c. the characteristics of hydrogen.
   d. the scientists who discovered each gas and the year of discoveries.

Reading

The Life-Supporting Gases

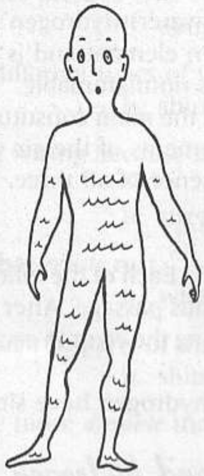
How long can a human being live without oxygen? What if there were no nitrogen in the air? Just how important is hydrogen?

Three of our most abundant and important elements are the gases oxygen, nitrogen, and hydrogen. Although they share many properties—all three are colorless, odorless, and tasteless at room temperature—each one is necessary to life in a unique way.

The same substance causes metals to corrode, wood to rot, apples to turn brown, paint to harden, gasoline to burn, and iron to rust. Fire cannot burn without it, and human beings cannot live without it. This substance is oxygen, an essential ingredient in air and water and the most abundant element in the earth's crust.

Oxygen is very active chemically, meaning that it readily combines with other substances in a process called oxidation. For example, iron combines with oxygen from the air to produce iron oxide, or rust. Food and water combine with oxygen to form decay. Vegetable oils used in paints combine with oxygen to harden. These are all examples of slow oxidation.

The rapid oxidation of fuels causes combustion, or fire. Sometimes a fire starts spontaneously. If a substance with a low kindling temperature, such as oily rags, newspapers, or grain, is heated in the absence of proper ventilation, oxidation may



Our bodies are two-thirds water.

occur so rapidly that the substance bursts into flames. This phenomenon is called spontaneous combustion.

Oxygen is found in the protoplasm of all living organisms and is essential to respiration. Human beings cannot live more than five minutes without oxygen. We inhale oxygen, which passes into the bloodstream and is carried to the body tissues. There it combines with the food we consume, producing the energy we need to maintain our body temperature and to supply us with the strength for physical activity.

Nitrogen is also vital to living things. All plants and animals contain nitrogen compounds in which the nitrogen has been converted to its free state by a process called nitrogen fixation. Fertilizers contain nitrogen compounds to feed plants and help them to grow.

In contrast to oxygen, nitrogen is comparatively inactive; that is, it does not readily combine with other substances. Therefore, nitrogen does not support combustion. If there were no nitrogen to dilute the oxygen in the air we breathe, the combustion of fuel would be extremely fast, metals would corrode rapidly, and smoking would be impossible. When, however, with the help of high temperatures, electricity, and catalysts, nitrogen does react with other elements, it tends to be very powerful. Because many nitrogen compounds are unstable, they are used in explosives like TNT and gunpowder. Other compounds include drugs such as poisons, antibiotics, laughing gas (nitrous oxide), and anesthetics. Nitrogen can be extracted from the air by liquefying air.

Hydrogen is the most abundant element in the universe. The sun and stars are almost pure hydrogen. Our sun's source of energy is the conversion of hydrogen into helium. Hydrogen is also found in almost all plant and animal tissues. There are more atoms of hydrogen in our bodies than any other element because our bodies are about two-thirds water! Hydrogen is also found in most fuels and in all acids. It is the lightest known element and is highly flammable. Helium is almost as light as hydrogen but it is nonflammable.

Hydrogen and oxygen are the main constituents of the water we drink. Nitrogen and oxygen are the chief elements of the air we breathe. Our existence could not be possible without the presence of all three.

Understanding the Reading. Each of the following statements is inconsistent with the information in the previous passage. After a careful reading of the passage, test your comprehension by finding the error in each statement and restating it correctly.

1. Oxygen, nitrogen, and hydrogen have similar properties, but only oxygen is essential to life.

   Oxygen, nitrogen, and hydrogen have similar properties, and all three are essential to life.

2. The substance that causes wood to rot is not the same as the one that causes apples to turn brown.
3. The decaying of food is an example of rapid oxidation.
4. It is impossible for a fire to start spontaneously.
5. Human beings can live up to 15 minutes without oxygen.
6. Nitrogen converts to a free state by a process called spontaneous combustion.
7. Compared to oxygen, nitrogen is very active.
8. If the air were pure oxygen, we could all smoke without harming our health.
9. Nitrogen is used in explosives because it is so stable.
10. Oxygen is the most abundant element in the universe.
11. Scientists do not know what the sun is made of.
12. Hydrogen is the most abundant element in our bodies because our bodies are mostly air.
13. In contrast to helium, hydrogen is nonflammable.
14. The essential ingredient in fertilizers is hydrogen.

LISTENING SKILLS

Vocabulary in Context. Circle the letter of the answer that best matches the meaning of the italicized word as it is used in each of these sentences.

1. We polished the car to give the finish a *luster*.
   (a.) shine   b. dullness

2. The *scarcity* of oil caused the price to rise.
   a. shortage   b. abundance
3. Iron can be molded into different types of tools because it is so *malleable*.
   a. easily shaped   b. shiny
4. Copper is used for electric wiring because it is a good conductor and very *ductile*.
   a. breakable   b. stretchable
5. Stainless steel is a metal that *resists* rust.
   a. absorbs   b. withstands
6. The acid had caused *corrosion* in parts of the engine.
   a. rust   b. shine
7. Many synthetic fabrics are more *durable* than cotton and will not shrink or fade.
   a. beautiful   b. long lasting
8. Carbon is *alloyed* with iron to produce steel.
   a. replaced   b. combined
9. Silver needs to be polished frequently because it *tarnishes*.
   a. shines   b. blackens
10. Icebergs float on the *surface* of the ocean.
    a. bottom   b. top
11. The image of the house was *reflected* in the water.
    a. repeated   b. absorbed
12. The *properties* of all heavy metals are similar.
    a. uses   b. characteristics
13. Metals are *conductors* of heat and electricity.
    a. preventors   b. carriers

Note-Taking

The purpose of taking notes is to record the main ideas of a lecture in order to study or review them later. You will take better notes if you read your textbook chapter before your class lecture. Prereading is useful for all students but essential for those who are studying in a foreign language. First, prereading will introduce you to new terms so that when you hear them in class you will recognize them and be able to understand and record them. Second, prereading will familiarize you with the basic concepts of the lesson. This will help you follow the development of the topic and focus on what you need to write down for recall.

Take notes as you listen to the lecture "The Precious Metals," and then use your notes to complete the next exercise.

Understanding the Lecture. Use your notes to determine whether each of the following statements is true (*T*) or false (*F*) according to the information in the lecture.

___T___ 1. Gold, silver, and copper are valued for their luster and scarcity.

______ 2. Newton was the first to succeed in changing base metals into gold.

______ 3. Copper is as malleable and ductile as gold.

______ 4. Gold is the most chemically active of all the metals.

______ 5. Gold has a beautiful luster but it is not as durable as silver.

______ 6. In contrast to gold, silver tarnishes.

______ 7. Pure silver is a relatively soft metal.

______ 8. Silver is used for photographic film because some silver compounds reflect light.

______ 9. The properties of silver resemble those of gold and copper.

______ 10. Gold is not used for electric wiring because it is not ductile.

______ 11. Copper is used for electric wiring because it is a better conductor than silver.

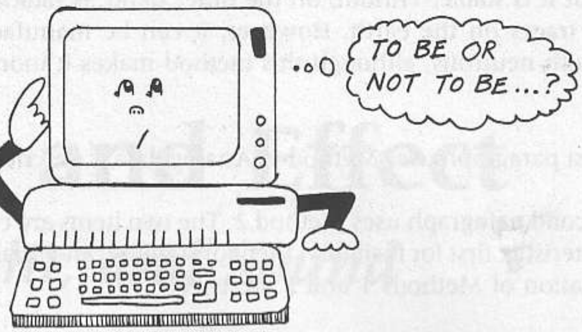
______ 12. Bronze, an alloy of tin and copper, is harder than either tin or copper.

______ 13. Gold, silver, and copper are among our most abundant metals.

DISCUSSION POINTS

To compare items, begin with their similarities and then point out their differences. Avoid vague statements such as, "Car A is better than Car B." In what specific ways are they different? Does Car A have a more powerful motor? a stronger body? a faster pickup? *Be specific.*

1. Compare a computer and the human brain. Computers have been programmed to translate from one language to another, to play chess, and to solve complex mathematical problems. Will they ever be able to think? Will they be able to analyze, evaluate, make decisions, and make judgments? Will they be able to design, imagine, or create?
2. Compare a sport or game that is popular in this country with one that is popular in your country.
3. Compare the foods of two countries you know. Why are they different?
4. Compare an American car with one from another country. Consider their power, reliability, comfort, cost, appearance, and workmanship.



5. Compare a painting and a photograph. What can each do that the other cannot?

WRITING SKILLS

Comparing

Scientific writing often requires a discussion of the similarities and differences among two or more items. There are two basic methods of comparing items:

Method 1: Describe the characteristics of the first item and then the characteristics of the second.
Method 2: Compare both items one characteristic at a time.

Read the examples below and determine which method is used in each.

The difference between analog and digital data is not always clearly understood, but it can be demonstrated. As an example, think of an elevator. There are two ways you can think about its position. If you ask how high up it is from the basement, and measure with a ruler, you will be measuring its analog position. That is, the length the ruler measures—47 feet, 6⅞ inches (approximately 14.5 m)—is an analog of how high up the elevator really is. If you tell what floor it's on, you are giving its digital position. It is either on the third floor or the fourth. It may be halfway in between, but there is no floor numbered 3½. Its height varies continuously and can never be measured precisely, while its floor number is discrete, one or another, even if you have to "watch your step."

Allen Wold, *Computer Science*
(New York: Franklin Watts, 1984),
pp. 28–29

Deuterium and tritium are two rare forms of hydrogen. Tritium fuses more easily than deuterium, although both fuse more easily than ordinary hydrogen. Deuterium is rare, but it is stable. Tritium, on the other hand, is radioactive and can only be found in traces on the earth. However, it can be manufactured by bombarding lithium with neutrons, although this method makes it more expensive than deuterium.

The first paragraph uses Method 1. Analog data is described first and digital data second.

The second paragraph uses Method 2. The two items are compared characteristic by characteristic: first for fusibility, then for stability, and finally for cost. Frequently, a combination of Methods 1 and 2 are used.

Transition Words

In all writing, it is very important to show how the ideas are related. Words that clarify these relationships are called transition words. Transition words that are used to show contrast include *although, but, however, in contrast, on the other hand, even though, nevertheless, on the contrary, yet, in spite of* and *despite.* Other transition words such as *similarly, likewise, in the same way, moreover, also, furthermore,* and *besides* express the comparison of like items.

Writing a Paragraph of Comparison

Write a paragraph of comparison on one of the Discussion Points. Begin with a topic sentence that states the main idea. Then develop the rest of the paragraph to support the main idea, using Method 1 or Method 2 described above.

chapter 3

Cause and Effect

Color, Light, and Sound

INTRODUCTION

The process of seeking relationships among scientific facts includes looking for cause and effect. The fifth-century B.C. Greek philosopher Leucippus suggested that there is causality in nature, that is, that every natural event has a natural cause. All science is based on this assumption. For example, something causes apples to fall, planets to stay in their orbits, the sun to emit energy, and a baby to be born with a defect.

Scientists must be careful, however, not to assume that one event caused another just because they happened in sequence. If there is an earthquake the day a comet passes near the earth, it cannot be assumed that the two events are related.

Sometimes the effect of one occurrence becomes the cause of a second event, and the effect of the second becomes the cause of a third. A nuclear reaction is an example of this kind of causal link. As one uranium atom is split, it releases neutrons that in turn split other uranium atoms. The result is a continuous chain reaction of causes and effects. It is the job of science to connect situations and events and thereby discover the how's and why's of our world.

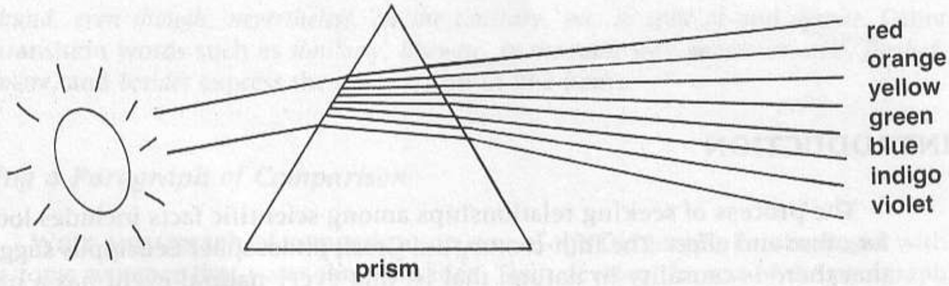
Short Reading

Read the passage below to discover what causes us to see different colors.

The Nature of Color

Why is the sky blue and the grass green? Why isn't the sky green and the grass blue? And why is a rose red instead of purple? What we see as color is the way our brains respond to the different wavelengths of light.

Light is a form of electromagnetic energy that travels very quickly on different frequencies, or wavelengths, which we see as different colors. For example, a wavelength of 400 nanometers (nm) causes us to see violet. A wavelength of 660 nm causes us to see red. The color brown is induced by the mixing of wavelengths. Yellow can be produced by either its own wavelength or a mixture of the wavelengths for red and green. Our sky looks blue because molecules of oxygen and nitrogen in the air scatter more blue wavelengths than any other color.



White light results from a mixing of the wavelengths of all colors. Sir Isaac Newton discovered that when sunlight passed through a glass prism, the white light dispersed into a spectrum of colored light. Newton then allowed the spectrum to pass through a second prism and the colors recombined, producing a beam of white light. This simple experiment demonstrated that white light contains all the colors of the spectrum. A beautiful and dramatic example of this occurs when sunlight falls on drops of water in the air after a rain. The beam of white sunlight spatters into a rainbow of colors.

Certain colors are invisible to human eyes. Wavelengths shorter than that of violet produce ultraviolet light that can damage skin cells. Wavelengths longer than that of the color red produce infrared light, radio waves, x-rays, and gamma rays. We cannot see colors produced by these wavelengths, but we can measure and use their energy.

USING ENGLISH TO SHOW CAUSE AND EFFECT

Causes and effects connect events or situations. Causes explain why something happens. Effects describe outcomes.

. . . a wavelength of 400 nanometers (nm) causes us to see violet.

CAUSE		EFFECT
wavelength of 400 nm	⟶	**we see violet**

The color brown is induced by the mixing of wavelengths.
(Sometimes the effect precedes the cause in the sentence. By definition, however, causes always precede effects.)

EFFECT		CAUSE
the color brown	⟵	**a mixing of wavelengths**

Yellow can be produced by either its own wavelength or a mixture of the wavelengths for red and green.
(Causes and effects are often complex. One effect may be produced by many causes, and one cause may produce many effects.)

EFFECT		CAUSES
yellow	⟵	**its own wavelength**
		OR
	↖	**a mixture of the wavelengths for red and green**

Wavelengths shorter than that of violet produce ultraviolet light that can damage skin cells.
(An effect can become a cause. Sometimes there is a cycle of causes and effects.)

CAUSE		EFFECT/CAUSE		EFFECT
wavelengths shorter than that of violet	⟶	**ultraviolet light**	⟶	**damaged skin cells**

White light results from a mixing of the wavelengths of all colors. . . . The beam of white sunlight splatters into a rainbow of colors.

(Sometimes there is a correlation between two events, that is, one event always accompanies the other, whether or not there is a causal connection.

CAUSE/EFFECT CAUSE/EFFECT

white light ⟶ a mixture of the wavelengths of all colors

a mixture of the wavelengths of all colors ⟶ white light

Sentence Patterns

A mixing of all wavelengths {causes / results in / produces / induces} a white light.

White light is {caused by / due to / induced by / a result of / produced by} a mixing of wavelengths.

{If / When / As} all the wavelengths are mixed, a white light is produced.

A white light is produced {if / when / as} all the wavelengths are mixed.

Note: Some of the above are also predictions and can be expressed with the future tense. For example, "If all the wavelengths are mixed, a white light will be produced." (Predictions will be discussed further in Chapter 12.)

Identifying Cause and Effect. The Roman orator Cicero wrote, "The causes of events are ever more interesting than the events themselves." In each of the following sentences, underline the cause once and the effect twice.

1. When copper is heated to 1083° C, it melts.
2. Changes occur in plants when they absorb energy from the sun.

3. The rotation of a compass needle is due to the earth's magnetic field.

4. Ashes result from the burning of wood.

5. Acids turn litmus paper red.

6. Rubbing a comb with a cloth produces a negative electric charge.

7. Fast-moving charged particles induce the ionization of atoms.

8. The ocean's tides are caused by the gravitational pull of the moon.

9. The more iron is exposed to moist air, the more it rusts.

10. Color is produced by the reflection of light.

Understanding Paraphrases. Circle the letter of the answer that best matches the meaning of each of these sentences.

1. Increasing the temperature increases the rate of a chemical reaction.
   a. Chemical reactions cause an increase in temperature.
   (b.) An increase in the rate of a chemical reaction may be caused by increasing the temperature.
2. Ions are formed when an acid is dissolved in water.
   a. Ions cause an acid to be dissolved in water.
   b. Dissolving an acid in water causes ions to be formed.
3. The closer the lines of force, the stronger the electric field.
   a. When the lines of force are closer, the electric field is stronger.
   b. The lines of force cause the electric field to be stronger.
4. Heating solid carbon dioxide (dry ice) produces a gas.
   a. A gas results from heating solid carbon dioxide.
   b. Carbon dioxide turns solid when heated.
5. Mirages are caused by light rays bending in the air.
   a. Mirages can result from light rays bending in the air.
   b. Mirages cause light rays to bend in the air.
6. Vibrations in the air cause the sound of the wind.
   a. Air vibrations are a result of the wind.
   b. The sound of the wind is a result of air vibrations.

Subordination

Subordination, or the connection of two clauses so that one is subordinate to or less important than the other, is frequently used in sentences that show cause and effect. Subordination allows you to focus on the important part of the sentence by putting it in a *main clause,* while the less important idea appears in the subordinate or secondary clause:

Human beings cannot live on the moon because there is no air or water there.

The main clause of this sentence, *human beings cannot live on the moon,* is *independent,* which means that it can stand alone as a sentence. The secondary, or less important, idea (*because there is no air or water on the moon*) is expressed in the *subordinate clause,* which is *dependent* on the main clause. It cannot stand alone as a sentence because it does not express a complete thought by itself.

Notice that the word *because* acts as a connector between the meanings of the two clauses. The connecting word always introduces the subordinate or less important clause. Note also that the clauses may be reversed. It is equally correct to say, *Because there is no air or water there, human beings cannot live on the moon.* Now the subordinate clause appears before the main clause. And, although the word *because* is not located between the clauses, it still acts as a connector since it relates the meaning of one to the other.

Recognizing Subordination. In each of the following sentences, identify the main clause by determining which clause contains the central idea. Underline the main clause once and the connecting word that links the clauses twice.

1. <u>No one was killed</u> <u>because</u> the avalanche occurred at night.
2. When silicon is added to iron, iron becomes rust resistant.
3. Even when heated to 1000° C, water will not decompose.
4. The gas pressure increased because the volume decreased.
5. When comets or meteors collided with the earth, the earth's magnetic field may have been reversed.
6. As the temperature increases, the rate of a chemical reaction increases.
7. Neon gives off light when an electric current is passed through it.
8. If carbon dioxide is cooled to −79° C, it condenses directly to a solid.

Using Subordination. In each of the following examples, combine the two clauses into one sentence so that one idea is subordinate to the other. You will need to add a connecting word such as *when, if, as, because,* or *so that.*

1. cause: mercury is heated to −38.9° C
   effect: it melts
   When mercury is heated to − 38.9° C, it melts.

2. effect: no sound can be heard
   cause: a bell is struck in a vacuum
3. cause: chlorophyll disintegrates
   effect: leaves turn red, yellow, and orange
4. effect: an echo is heard
   cause: a sound wave reflects off a mountain
5. effect: ions are formed
   cause: an acid is dissolved in water
6. cause: a lens is too thin or an eyeball is too short
   effect: a person becomes farsighted

Recognizing Cause and Effect in a Paragraph. Read the following description of an experiment and then answer the questions that follow.

STORED ENERGY

In a laboratory, chemistry students put some water into a beaker. They found the temperature of the water to be 19° C. Then they added pellets of sodium hydroxide to the water. To speed up the reaction, they stirred the pellets, causing them to break into sodium and hydroxide ions. When they were all dissolved, the students measured the temperature of the water again and found it to be 22° C. They thus learned that there is *energy stored in the chemical bonds of sodium* hydroxide. The breaking of those bonds resulted in the release of energy (3° C of heat), causing the temperature of the water to rise.

1. What caused the sodium hydroxide to break up?
2. What activity speeded up the reaction?
3. What caused the release of energy?
4. What caused the temperature of the water to rise?
5. What was the immediate effect of putting the sodium hydroxide pellets in water?
6. What was the effect of stirring the pellets?
7. What was the effect of breaking the bonds of sodium hydroxide?
8. What was the effect of the release of energy?

READING SKILLS

Vocabulary Building

An English word is formed from a root, which is its main part. Many words also contain prefixes, which come before the root, or suffixes, which follow the root, or both. (More than half of all commonly used English words are formed at least partly from Greek or Latin prefixes and roots.) Knowing the parts of a word can often be useful in determining its meaning. For example, knowing that the prefixes *un-*, *im-*, *in-*, *dis-* and *il-* make a word negative will tell you that *unnecessary* means *not necessary*, *impossible* means *not possible*, *inaccurate* means *not accurate*, *disconnected* means *not connected*, and *illogical* means *not logical*.

A word of caution is needed, however, for you cannot rely completely on such clues to determine meaning. English is a language that has evolved and changed over many years, absorbing words from many languages. The clues can sometimes be misleading. For example, *flammable* and *inflammable* have the same meaning! They both refer to something that can easily catch fire. (The antonym is *nonflammable* or *uninflammable*.) Therefore, you must always see if the meaning that you guessed fits the way the word is used in the sentence.

Prefixes: hyper-, hypo-, post-, sub-. Study the following list of prefixes and then match the terms at the left below with their meanings at the right. You will not use all the meanings listed.

***hyper-*: over, above, beyond the norm; *hypertension* = high blood pressure**

***hypo-*: under, beneath, less than the norm; *hypotension* = low blood pressure**

***post-*: after; *postglacial* = after the glacial period**

***sub-*: under; *submarine* = a ship used under water**

__c__ 1. hypothermia	a. put under water
______ 2. hypotoxic	b. less poisonous
______ 3. hypoacidic	c. subnormal body temperature
______ 4. hyperventilation	d. beneath the bottom of the sea
______ 5. hypersonic	e. less acidic
______ 6. postoperative	f. more acidic
______ 7. postmortem	g. excessive breathing
______ 8. submerge	h. highly poisonous
______ 9. suboceanic	i. faster than the speed of sound
	j. after the operation
	k. after death

Vocabulary in Context. Circle the letter of the answer that best matches the meaning of the italicized word as it is used in each of these sentences.

1. The best way to solve a problem is to find the *source*.
   a. origin — b. effects
2. Although he had no information, his *intuition* led to a solution of the problem.
   a. feeling — b. knowledge
3. The space between the earth and the moon is a *vacuum*.
   a. empty — b. full
4. The glass door was so *transparent*, we bumped into it.
   a. strong — b. clear
5. Fleming *revealed* that his discovery of penicillin was accidental.
   a. made known — b. kept hidden
6. The two paths *diverge* at the lake, as one goes north and the other goes east.
   a. come together — b. separate
7. The earth *absorbs* the water from the rain.
   a. drinks in — b. gives off
8. Wood is *opaque;* no light passes through it.
   a. unclear — b. clear
9. The *image* of the house was reflected in the water.
   a. picture — b. roof
10. The driver went in the *reverse* direction.
    a. identical — b. opposite
11. Air is the *medium* through which sound travels.
    a. process — b. environment
12. The old building was *transformed* into an emergency hospital.
    a. enlarged — b. changed
13. A microscope *magnifies* invisible objects so we can see them.
    a. enlarges — b. reduces
14. All efforts were *concentrated* on landing the plane safely.
    a. centered — b. scattered

Scanning

When you need to search technical material for the answers to specific questions, you will want to locate the particular information without reading every word. This can be accomplished by *scanning* the passage. To scan let your eyes run rapidly down the page and look for the key or important words that you are seeking.

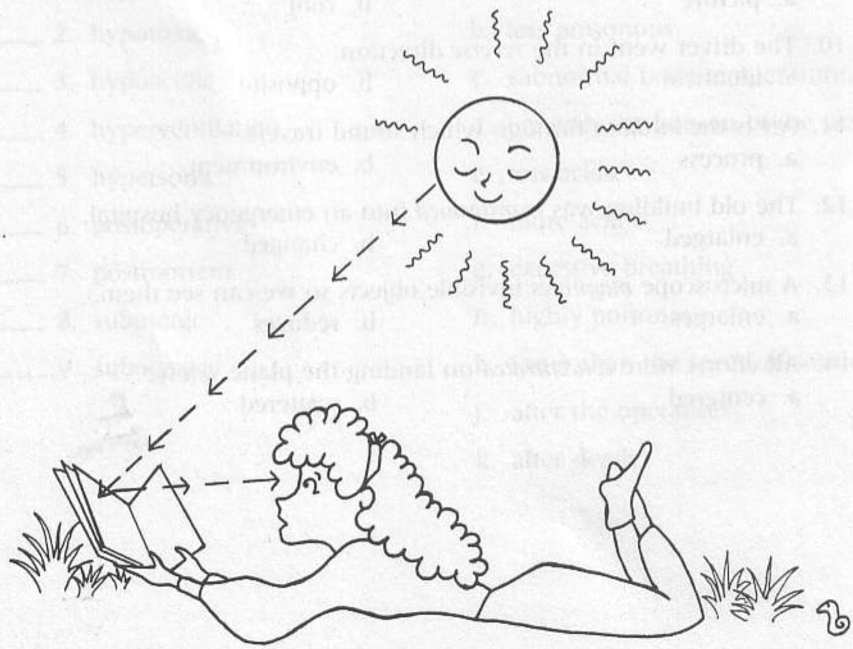
Read the following three questions. Then find the answers by scanning the passage for the key words. Try to do it all in three minutes.

1. What is the speed of light? (key words: a large number)
2. Who originated the wave theory of light? (key words: a proper name with capital letters)
3. What is silver bromide used for? (key words: silver bromide)

Reading

Reflecting on Light

Most of what we know about the world comes to us through our ability to "see" with our eyes, our telescopes, and our microscopes. But how do we see? Sight is not something that reaches out *from* our eyes. Instead it is the light that travels *to* our eyes. You see this page, for example, because light, reflecting from the sun or an electric light, travels from the paper to your eyes.

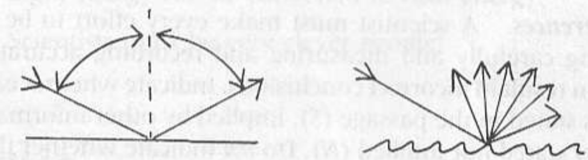


Sometimes we see light as it comes from a direct source, such as the sun, fire, lightning, or a light bulb. The rest of the time we see light as it is reflected off objects.

Light travels at high speeds. It must have been a great leap in the intuition of scientists to realize that light actually "travels." It isn't just there! In the air light travels at a speed of 186,000 miles per second. It travels slightly faster in a vacuum and slower in other transparent materials such as water or diamonds. It takes light less than one minute to travel from the earth to the moon and about 15 minutes to go from the earth to the sun.

In 1678 the Dutch scientist Christian Huygens was the first to propose that light travels in waves. Since then the work of the American Albert Einstein and the Scottish James Maxwell has revealed that light actually consists of particles known as photons and travels in electromagnetic waves. Light seems to travel in straight lines. If you shine a flashlight in the dark, for example, the beam of light appears to be straight. In contrast, sound waves travel in every direction. We can hear people on the other side of a wall but cannot see them.

In certain situations light diverges from a straight path. When it falls on an object, most is either absorbed (in the case of an opaque object such as wood or metal) or passes through (in the case of a transparent object such as water or glass). The remainder of the light is reflected. It is reflected light that changes direction. When light is reflected off a smooth surface, it changes direction in a regular way, that is, the angle that is reflected equals the angle at which it strikes the surface. If the surface is rough, light is reflected in many directions.



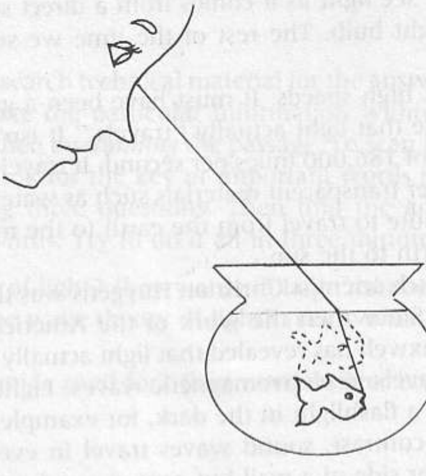
Light reflecting off a smooth surface.

Light reflecting off a rough surface.

Certain silver compounds (like silver bromide) reflect almost all the light that falls on them and are accordingly used for mirrors. The image that is reflected in a flat mirror is identical to the original object, even in size, except that the image is reversed. This is because light on a flat surface changes direction.

When light passes from one transparent medium to another, it changes speed and direction. This process, called refraction, explains the apparent shortening of a person's legs or the bending of a stick in water.

Light is a form of energy that can be transformed into heat. You can prove this by using a magnifying glass to concentrate the sun's rays on a piece of paper and



Light rays change direction in water.

burn a hole in it. It is this light energy from the sun that warms the earth and enables living things to grow. Plants get light energy directly from the sun. Animals get it from the plants they eat.

Making Inferences. A scientist must make every effort to be precise by reading and observing carefully and measuring and recording accurately. Inaccurate information can result in incorrect conclusions. Indicate whether each of the following statements is stated in the passage (*S*), implied by other information in the passage (*I*), or neither stated nor implied (*N*). Do *not* indicate whether the statement is true or false.

__S__ 1. The speed of light is 186,000 miles per second.

______ 2. Light travels slower through glass than through air.

______ 3. Light travels faster than sound.

______ 4. Moonlight is reflected light.

______ 5. Light travels faster through water than sound does.

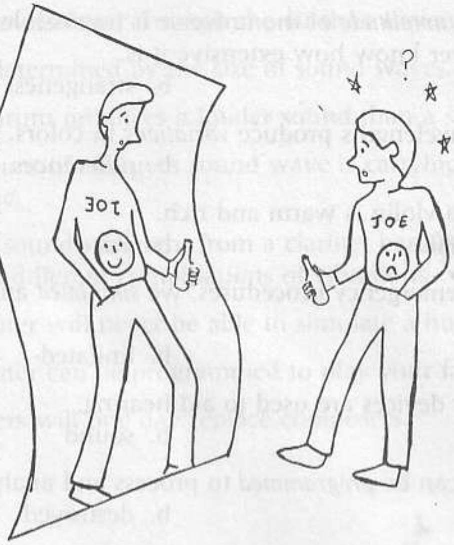
______ 6. Scientists did not always know that light travels.

______ 7. Light travels in the same way as sound.

______ 8. Light travels at different speeds in different substances.

______ 9. Sound waves do not travel in straight lines.

______ 10. Most of the sound we hear is reflected.



_______ 11. Most of the sunlight falling on the tin roof of a building is absorbed.

_______ 12. An opaque object reflects more light than a transparent one.

_______ 13. A flat mirror reflects a reversed image.

_______ 14. Light energy can be converted to heat energy.

_______ 15. Scientists must be very clever people!

LISTENING SKILLS

Vocabulary in Context. Circle the letter of the answer that best matches the meaning of the italicized word as it is used in each of these sentences.

1. Heavy machinery will produce *vibrations* that you can feel in the floor.
   a. noises   b. movement
2. In general, women's voices have a higher *pitch* than men's.
   a. sound   b. color
3. Sunglasses protect our eyes from the *intensity* of the sun's rays.
   a. strength   b. weakness
4. Tropical climates are characterized by a high *frequency* of rainfall.
   a. quality   b. recurrence
5. His poor health was *induced* by improper diet and smoking.
   a. prevented   b. caused

6. Because the *amplitude* of the universe is impossible for us to comprehend, we may never know how extensive it is.
   a. largeness b. strangeness

7. Different wavelengths produce *variations* in colors.
   a. styles b. differences

8. The *tone* of a violin is warm and rich.
   a. sound quality b. price

9. To practice emergency procedures, we *simulated* an actual earthquake situation.
   a. observed b. imitated

10. Tiny *acoustic* devices are used to aid hearing.
    a. visual b. sound

11. Computers can be *programmed* to process and analyze all kinds of data.
    a. designed b. destroyed

12. All theoretical research was suspended for the *duration* of the war.
    a. period b. benefit

Note-Taking

When taking notes during a lecture, always focus on the main ideas. Listening for the main points is like looking for the topic sentences in a reading passage, although it is more difficult because you do not have paragraph clues to help you. You thus must listen for the general ideas or conclusions of the lecture.

Find out the topic or title of the lecture so you will have an idea of what it is going to cover and what you need to listen for. Sometimes the speaker states the objectives at the beginning of the presentation. Occasionally a speaker writes important points on a chalkboard or displays them on a slide or transparency. Finally, the speaker may summarize the main points of the lecture at the end.

Take notes as you listen to the lecture "The Music of Sound." Try to write down all the main ideas. Then use your notes to complete the next exercise.

Understanding the Lecture. Use your notes to determine whether each of the following statements is true (*T*) or false (*F*) according to the lecture.

__T__ 1. Sound is produced by air vibrations.

_____ 2. Sound waves move in only one direction.

_____ 3. A bell rung in a vacuum will not produce a sound.

_____ 4. We hear sound when our ear drums vibrate and send messages to our brain.

_______ 5. Sound travels faster through the air than through the ground.

_______ 6. Pitch is determined by the size of sound waves.

_______ 7. A large drum produces a louder sound than a small one.

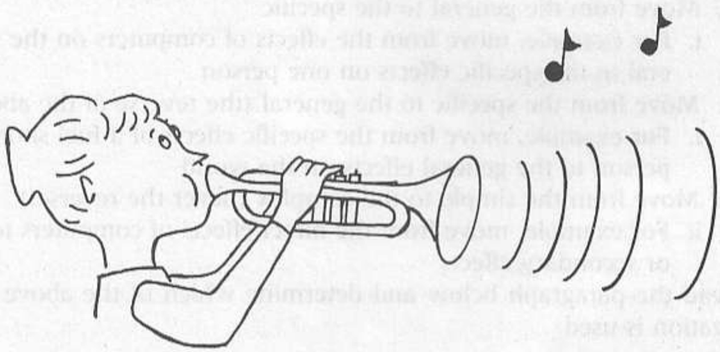
_______ 8. The amount of energy a sound wave is carrying is referred to as its amplitude.

_______ 9. A guitar sounds different from a clarinet because each instrument produces different combinations of vibrations.

_______ 10. A computer will never be able to simulate a human voice.

_______ 11. A computer can be programmed to play your favorite tune.

_______ 12. Computers will one day replace composers.



DISCUSSION POINTS

1. What are some of the beneficial effects of the technological advances in science in this century?
2. What are some of the harmful effects of modern technology?
3. What are some of the effects of space exploration?
4. What causes men and women to travel into space?
5. What might be the effects on earth of the discovery of life on another planet?
6. What are the possible effects of a continued expansion of world population?
7. What are some possible effects of a fuel shortage?
8. What are the effects of the computer on your life?

WRITING SKILLS

Patterns of Organization

When writing a paper, choose a logical order to present your information so that one idea leads to another. You might organize your paper according to one of the following concepts:

1. Time (chronology)
   a. For example, move from the initial effects of computers to the current effects to the possible future effects
2. Space
   a. For example, move from the effects of computers at home to the effects at your school to the effects at a work place such as a store, bank, or airline office
3. Logic
   a. Move from the general to the specific
      i. For example, move from the effects of computers on the world in general to the specific effects on one person
   b. Move from the specific to the general (the reverse of the above)
      i. For example, move from the specific effects of a fuel shortage on one person to the general effects on the world
   c. Move from the simple to the complex (never the reverse!)
      i. For example, move from the direct effects of computers to the indirect or secondary effects

Read the paragraph below and determine which of the above patterns of organization is used:

In 1954 a hydrogen bomb was tested at Bikini. The explosion produced the expected radio-active fall-out on a number of Pacific islands, and also scattered debris over thousands of square miles. As a result, dangerous radio-active materials appeared in the small plants which live in the surface of the sea; these were eaten by small animals which in turn were eaten by larger animals, notably the tuna fish which are an important article of diet in Japan. Hence a number of Japanese ingested quantities of radio-active food.

S. A. Barnett, *The Human Species: A Biology of Man* (Harper & Row, 1971), p. 208

In this paragraph, the effects of a hydrogen bomb test are described in chronological order because it is a chain reaction, that is, each effect in turn becomes the cause of another. These effects are introduced with the words *produced, as a result*, and *hence*. Other words that can introduce effects include *caused, induced, consequently, thus*, and *therefore*. Transition words that introduce causes include *is caused by, is produced by, is induced by, happens because*, and *is due to*.

Writing a Paragraph of Cause and Effect

Choose one scientific discovery or invention and write about its effects on your world. Or write about one of the Discussion Points. Use whatever pattern of organization (time, space, or logic) seems to work best for your topic, but be consistent throughout the paper. Start with a topic sentence that is broad enough to include everything you want to put in the paragraph.

chapter 4

Hypothesizing

Motion and Gravity

INTRODUCTION

When a scientist discovers a relationship that seems to hold true without exception, he or she formulates a *hypothesis*. A hypothesis is a tentative or temporary solution to a scientific problem or an explanation for why something happens. Although a hypothesis usually develops from the intuition of the scientist, it is based on observations or facts. For example, Charles Darwin's hypothesis about evolution came to him while he was riding in a carriage (he wrote, "I can remember the very spot in the road"), but the idea was the product of many years of study and experimentation.

A hypothesis does not always prove to be correct, and it may have to be rejected altogether or at least revised. Progress involves continually refining hypotheses as new information comes to light. For example, since no one has ever seen the structure of an atom, scientists continually revise their hypothesis about what it looks like.

As evidence is gathered to support a hypothesis and it becomes accepted in the scientific world, it is referred to as a *theory* (for example, the theory of relativity). When a theory explains or unifies a great deal of information, it becomes known as a *principle,* or *natural law* (for example, Archimedes' principle of water displacement or the law of gravity).

Short Reading

Read the passage below and find Aristotle's and Galileo's hypotheses about motion.

Some Notions About Motion

Which falls faster, a blade of grass or a stone? Anyone can see that a stone falls faster. And that is what the ancient Greeks believed. Based on everyday experience, Aristotle determined that heavy objects fall faster than light objects and that objects fall with a speed proportional to their weight.

Aristotle also studied horizontal motion. He observed that whenever he pushed a rock or other object, it always rolled for a while and then came to rest. He hypothesized that the natural state of an object is to be at rest and a force is necessary to keep an object in motion. Aristotle's hypotheses were accepted for two thousand years because they were consistent with logic and informal observation.

It was not until the early 1600s that these long-established beliefs were challenged. Galileo was not content to accept ideas without verifying them with experiments. He dropped various weights from a height and recorded the results. Disproving Aristotle's hypothesis, he determined that all bodies fall at equal rates, if you discount the air resistance. A blade of grass will fall more slowly than a stone only because it meets with more resistance from the air.

Galileo also disproved Aristotle's hypothesis about horizontal motion. He demonstrated that a body pushed on a smooth surface could go much further than one pushed on a rough surface. When a lubricant such as oil was used, almost no force was required to keep the object in motion. He concluded that if an object does not meet with resistance (friction), it will continue to move at a constant speed even if no force is applied.

Half a century later, Newton extended Galileo's ideas and formulated a theory that a body at rest will remain at rest and a body in motion will remain in motion unless some outside force acts on it. This theory is so universally accepted it is referred to as Newton's first law of motion.

USING ENGLISH TO HYPOTHESIZE

A hypothesis is a tentative proposition that resolves a problem or answers a scientific question. A theory is a hypothesis that is generally accepted. However, the words *hypothesis* and *theory* are frequently used interchangeably.

The following are examples of hypotheses from the reading:

Aristotle's hypotheses: **Objects fall with a speed proportional to their weight.**

The natural state of an object is to be at rest and a force is necessary to keep an object in motion.

Note that although it may appear within a sentence, the hypothesis itself is always in the form of a complete sentence, *not* a sentence fragment or a question.

Galileo's hypotheses: **All bodies fall at equal rates.**

If an object does not meet with resistance, it will continue to move at a constant speed even if no force is applied.

Most hypotheses are stated in the present simple tense, although it is possible to hypothesize about something that happened in the past or will happen in the future. Sometimes a hypothesis is expressed as a prediction, using the future tense with *will*. The meaning is the same as if the present tense were used. Saying something always happens is the same as predicting that it will happen.

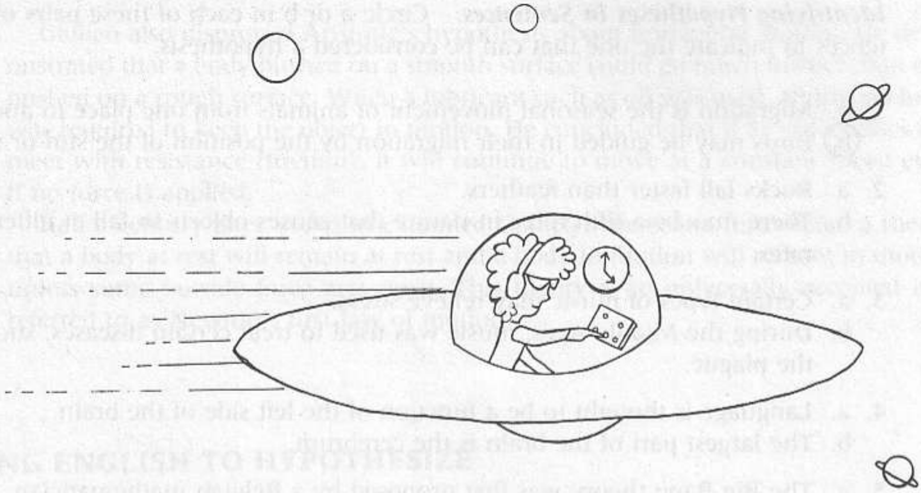
Identifying Hypotheses in Sentences. Circle a or b in each of these pairs of sentences to indicate the one that can be considered a hypothesis.

1. a. Migration is the seasonal movement of animals from one place to another.
   (b.) Birds may be guided in their migration by the position of the sun or stars.
2. a. Rocks fall faster than feathers.
   b. There may be a fifth force in nature that causes objects to fall at different rates.
3. a. Certain types of music may relieve stress.
   b. During the Middle Ages, music was used to treat certain diseases, such as the plague.
4. a. Language is thought to be a function of the left side of the brain.
   b. The largest part of the brain is the cerebrum.
5. a. The Big Bang theory was first proposed by a Belgian mathematician, Abbé Georges Lemaître, in 1927.
   b. The universe was born about 18 billion years ago when a cosmic egg, containing all the matter and energy existing in the universe today, exploded into millions of pieces.
6. a. Some elephants, whales, dolphins, and porpoises have brains larger than the human brain.
   b. Dinosaurs may have become extinct because their brains were not proportional to their brawn.
7. a. Excessive amounts of cholesterol might cause heart attacks.
   b. Eggs, cheese, and fatty meats all contain cholesterol.

Identifying a Hypothesis in a Paragraph. Underline the hypothesis or theory in the following paragraph.

WHAT TIME IS IT?

Suppose a football game begins at 1:00 P.M. in New York City. It is then 10:00 A.M. in Los Angeles and 6:00 P.M. in London. Which time is correct? If an explosion occurred on a star, scientists on the earth would register the time it happened. But anyone traveling in another part of the universe in a different direction would identify the time differently. Thus time, like space and motion, is relative; there is no real or absolute time. This concept was brought to the attention of the world by Albert Einstein in 1905.



Probability

Hypotheses are often expressed with words that indicate their tentative nature or unproven status. These words are very important. To say "there is life on Jupiter" is entirely different from saying "there may be life on Jupiter." In the following list, the first sentence expresses probability most strongly and each succeeding sentence expresses it slightly less strongly.

There is life on Jupiter.
There must be life on Jupiter.
There is probably life on Jupiter.
There may be life on Jupiter.
There could be life on Jupiter.
There might be life on Jupiter.
It is unlikely that there is life on Jupiter.
It is impossible for there to be life on Jupiter.
There is no life on Jupiter.

Identifying Probability. There are many ways to express probability. Circle the word or words that indicate probability in each of these sentences.

1. Light (seems) to travel in waves.
2. The accumulation of carbon dioxide in the air is believed to be warming the earth to a dangerous level.

3. Pulsars are thought by some scientists to be rapidly spinning neutron stars.
4. Current research suggests that obesity is hereditary.
5. The universe appears to be expanding.
6. As far as we know, the earth is 4.6 billion years old.
7. It is possible that the universe is expanding and contracting in some rhythmic way.
8. Theoretically, computers will be able to design and create in ways that are undreamed of today.

Using Modals of Probability. Modals are a group of auxiliary verbs that modify verbs. Probability may be expressed with the use of the modals *must, may, might,* and *could*. The modal *must* conveys a much stronger probability than the others. In scientific writing, these modals are frequently used with the verb *to be*. Formulate sentences with either *must be, may be, might be,* or *could be* following the pattern of the first pair of sentences below.

1. Is the "greenhouse effect" warming our earth?
   The "greenhouse effect" may be warming our earth.
2. Are the pandas in China becoming extinct?
3. Are the ocean's tides slowing the rotation of the earth?
4. Are quasars violently exploding galaxies?
5. Are the continents drifting or moving on the surface of the earth?
6. Is the radioactive fallout from nuclear test explosions harmful to the atmosphere?
7. Is the population of the world increasing at a dangerous rate?
8. Are computers revolutionizing industry around the world?

READING SKILLS

Vocabulary Building

A knowledge of prefixes and other word parts will not only help you identify new words but also greatly expand your vocabulary. Just knowing that the prefix *re-* means *again* can vastly increase the number of verbs you know. For example, *re- + write = rewrite* (meaning *to write again*). Similarly, *re-* may be added to many other English verbs to form new verbs. Examples include *recalculate, readmit, re-release, reproduce, reenter, reactivate, recharge, reorganize, reappear, redirect, reapply, reexamine,* and *retest*.

However, a warning is necessary for students of English as a second language. Many English words begin with the letters *re* but not the prefix *re-*, such as: *resource, revolve, reject, reflect, resist, refuse, reserve, resemble, reveal, refer,* and *reduce*. Interestingly, although there are many such verbs, they often contain the meaning of *again* or a repeated action, as is true of *renew, repeat, review, revive, return, remember,* and *reciprocate*.

Prefix: trans-. Study the following prefix and then complete the sentences below, using a dictionary if necessary.

trans-: over, across, beyond, through

translucent—allowing light to pass through

1. Metal and wood are opaque; glass and water are *trans*parent______.
2. Maria does not speak English, so you will have to *trans*____________ for her.
3. The hospital patient received a blood *trans*____________.
4. A *trans*____________ in a radio amplifies the signal without using a vacuum tube.
5. Sound is *trans*____________ in waves; it cannot travel through a vacuum.
6. The professor *trans*____________ to another university in his hometown.
7. Many lives are saved by kidney and liver *trans*____________ from one person to another.
8. Light energy can be *trans*____________ into heat energy.

Vocabulary in Context. Circle the letter of the answer that best matches the meaning of the italicized word as it is used in each of these sentences.

1. The results of the experiment *verified* that our theory was correct.
   a. disproved (b.) proved
2. The lesson was *extended* one hour to allow time for questions.
   a. lengthened b. shortened

3. The *horizontal* lines on the map indicate east-west routes.
   a. side-to-side   b. up-and-down

4. The structure is resting on four *vertical* posts.
   a. level   b. up-and-down

5. His *inertia* was caused by hot weather and fatigue.
   a. activity   b. inactivity

6. The truck *accelerated* when it started downhill.
   a. slowed down   b. speeded up

7. The automobile tires were worn out by *friction*.
   a. age   b. rubbing

8. Europe and Asia make up the largest land *mass* on earth.
   a. ocean   b. body

9. The students' names were listed in *inverse* alphabetical order.
   a. correct   b. reverse

10. The *proportion* of hydrogen to oxygen in water is 2 to 1.
    a. relationship   b. distance

11. The researchers were pleased because the results of the experiment *were consistent* with their expectations.
    a. agreed   b. disagreed

12. The football game was a good match because the two teams were *balanced*.
    a. equal   b. strong

13. The design of the Taj Mahal in India is *symmetrical*; all sides are equal.
    a. regular   b. irregular

14. We had to rest after *exerting* all our energy to push the car up the hill.
    a. using   b. saving

15. Automobiles *expel* carbon monoxide, which pollutes the air.
    a. give off   b. absorb

16. The wind *propelled* the sailboat along the water.
    a. pulled   b. pushed

17. The humidity *altered* the results of the experiment and we had to redo it.
    a. changed   b. improved

18. Water can be formed by the *synthesis* of hydrogen and oxygen.
    a. separation   b. combination

19. It is *logical* to assume that the next century will be more advanced technologically than this one.
    a. unreasonable   b. reasonable

Finding Main Ideas

A good way to read any textbook is to bracket or highlight the topic sentence of each paragraph or section. Later, to review the material for a test, you only need to read the topic sentences for a summary of all the main points.

Reading

Put square brackets around the topic sentence of every paragraph in the following passage. Note that here the topic sentences are usually found toward the ends of the paragraphs because the information builds up to a conclusion.

Newton Explains Motion

[Although many scientists studied motion, it was the great Sir Isaac Newton who formulated the theories of motion, verifying and extending the earlier work of Galileo and Copernicus.] Newton studied horizontal and vertical motion.

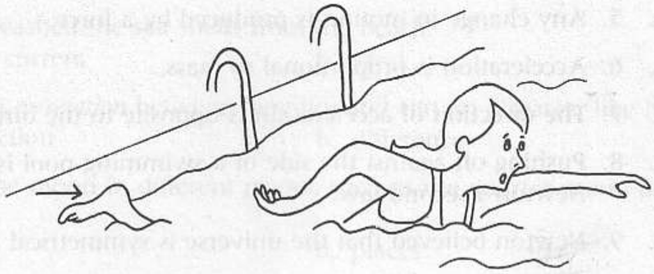
First Newton studied the quality of inertia, or the tendency of a body to resist change in its state of motion or direction. A tennis ball, for example, has little inertia; it is easy to get it to move, stop, or change direction. A truck, on the other hand, has a great deal of inertia. Newton concluded that a body at rest will remain at rest and that a body in motion will remain in motion unless some outside force acts on it. This principle is called the law of inertia, or Newton's first law of motion.

But Newton's curiosity was not satisfied. He wondered what causes a change in motion. Why does a body at rest begin to move or a body in motion change its direction? He determined that if a body is at rest, no force is acting on it; however, when a force acts on a body, the force will speed up, slow down, or change the direction of that body.

Moreover, Newton discovered that there is a relationship between force and acceleration. If you push a swing gently, it will move slowly. If you push it harder, it will go faster. Newton noted that if you discount the friction involved, the amount of force is directly related to the amount of acceleration.

The acceleration is also related to the mass of the object. Mass, which is the quantity of matter in a body, also determines the amount of inertia an object has. A truck has a great deal of mass, a bicycle has much less. If you use an equal amount of force to push a bicycle and a truck, the bicycle will go much faster than the truck. The larger the mass, the less the acceleration. In fact, the acceleration of a body is inversely proportional to its mass. Newton's second law of motion states that the acceleration of a body is directly related to the force acting on it and inversely proportional to its mass. The direction of the acceleration is in the direction of the applied force.

Finally, Newton explored the question of the source of force. He observed that the force acting on a body comes from another body. But this idea by itself was not consistent with his view of a balanced and symmetrical universe. He therefore concluded that whenever there is a force pushing in one direction, there is another



When you push a wall, it exerts an equal and opposite force on you.

force pushing back. This concept may be difficult to imagine, but try pulling on a rubber band and you will feel it pulling back on you. Also notice what happens to your finger when you press it against a table. Objects can exert a force because all materials are elastic to some extent, although the elasticity of walls and tables may be slight. When you push off against the wall of a swimming pool, for example, you start to move away from the wall. The wall is exerting a force on you that causes you to move in the opposite direction. And if you think the floor does not push back against your feet, why do your shoes wear out, and why do your feet hurt you after you have been on them for a long time? Why do automobile tires wear out? Thus Newton stated his third law: whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first.

The movement of a rocket is also based on this law. The rocket expels gases, which then exert an equal and opposite force propelling the rocket forward. In space, a vehicle can alter its speed or direction by expelling rockets in the opposite direction.

Newton's laws are applicable everywhere in the universe and synthesize both vertical and horizontal motion. The concept that the universe functions according to logical, orderly natural laws influenced not only the scientific world but also the social, political, and philosophical thinking of the Western world for two hundred years.

Understanding the Reading. Indicate whether each of the following sentences is true (*T*) or false (*F*) according to the information in the passage above.

__F__ 1. Although many scientists studied motion, Newton was the first.

_____ 2. Galileo's ideas were based on Newton's work.

_____ 3. Newton's third law is the law of inertia.

_____ 4. Inertia is the tendency of a body to resist change.

_______ 5. Any change in motion is produced by a force.

_______ 6. Acceleration is proportional to mass.

_______ 7. The direction of acceleration is opposite to the direction of force.

_______ 8. Pushing off against the side of a swimming pool is an example of Newton's second law.

_______ 9. Newton believed that the universe is symmetrical and balanced.

_______ 10. Every action produces an equal and opposite reaction.

_______ 11. A rocket functions on the principle of action and reaction.

_______ 12. According to Newton, your shoes wear out because you are wearing the wrong brand.

_______ 13. Newton's ideas influenced world thinking in fields other than science.

LISTENING SKILLS

Vocabulary in Context. Circle the letter of the answer that best matches the meaning of the italicized word as it is used in each of these sentences.

1. Gravity keeps the moon in its *orbit* around the earth.
   a. path　　b. position
2. Scientists are still *speculating* about the origin of the universe.
   a. thinking　　b. experimenting
3. Objects fall downward because of the earth's *gravity*.
   a. pull　　b. movement
4. The professor was always on time and began the lecture *precisely* at noon.
   a. approximately　　b. exactly
5. Your weight *varies* from day to day.
   a. changes　　b. increases
6. Astronauts experience *weightlessness* when traveling in space.
   a. no weight　　b. heaviness
7. The *relative* advantages of copper and silver wire were studied and compared.
   a. comparative　　b. important
8. Newton *calculated* the size of the planets.
   a. computed　　b. reported

9. The *tide* washed the sea shells from the beach.
   a. ocean current b. sand
10. There is a *correlation* between heredity and certain diseases, like hemophilia.
    a. connection b. difference
11. We see the moon in different *phases*, such as the quarter-moon and half-moon.
    a. stages b. places

Note-Taking

Taking notes is a challenging task. The chief problem is that while you are writing, the instructor is still talking and may be making important points that you are missing. Even a native speaker cannot listen to one thing and write something else at the same time while concentrating on both.

Therefore, you must write quickly. One good way to do this is to use shortened forms of long words as well as symbols and abbreviations. It is *not* necessary to know standard abbreviations. You may use your own as long as you can write them quickly and read them back later. The following hints may help:

1. Write only the first part of a long word.

scientific knowledge	**sci knowl**
chemically active	**chem act**
atmospheric pressure	**atmos press**

2. Use symbols and abbreviations.

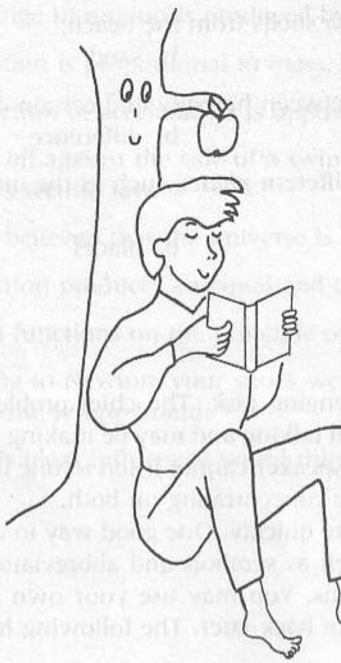
Malleable and ductile	**mall & duct**
one gram	**1 gm**
ninety percent	**90%**
mix with water	**mix w/H_2O**

Note: Only use shortened forms of words you are familiar with! If a word is new, write it out.

Take notes as you listen to the lecture "Obeying the Law of Gravity," and then use your notes to complete the next exercise.

Understanding the Lecture. Indicate whether each of the following sentences is true (*T*) or false (*F*) according to the information in the lecture.

__F__ 1. Newton demonstrated that movement on the earth is different from movement in the heavens.



_______ 2. Planets are held in their orbits by the force of gravity.

_______ 3. Your mass would be different on Mars.

_______ 4. Astronauts weigh less on the moon because there are no good restaurants there.

_______ 5. Astronauts experience weightlessness while traveling in space because they are too far from the gravitational pull of the earth or the moon.

_______ 6. Newton calculated the relative weights of the planets by studying their gravitational pull.

_______ 7. There is a stronger force of attraction between the sun and the earth than between the earth and the moon.

_______ 8. The ocean's tides are caused by eclipses.

_______ 9. You cannot feel the gravitational pull between yourself and the person sitting next to you because it is so weak.

_______ 10. The law of gravity is universal and applies everywhere.

DISCUSSION POINTS

1. Form a hypothesis to explain why some students succeed in their school work while others, with equal ability, fail.
2. Form a hypothesis to explain why some students experiment with drugs.
3. Form a hypothesis to explain why some students drop out of school.
4. Form a hypothesis to explain why some people do not wear seat belts in their cars.
5. Form a hypothesis to explain why many drivers go faster than the speed limit.
6. Form a hypothesis to explain why some students, although honest in other ways, will cheat on a test.
7. Form a hypothesis to explain why some students seem to make friends easily, while others do not.

WRITING SKILLS

Writing Conclusions

A short paragraph does not require a concluding statement, but a longer paper should have a conclusion instead of just ending abruptly. A conclusion is important because it is the final thought given to the reader and thus has the strongest impact. Therefore, the conclusion should contain whatever you want the reader to remember. A concluding sentence may do one of the following:

1. Restate the main point for emphasis. This involves paraphrasing or rewriting the topic sentence.
2. Summarize the information to review or clarify it. In a short paper, a summary may not be different from the main point.
3. Relate the significance of what was written. Why is it important? What effect will it have? What can be done about it? What should the reader do?

Transition words for writing a conclusion include *therefore, as a result, for this reason, thus, hence, consequently, so, because of this,* and *for this reason.*

Writing a Paragraph with a Conclusion

Write a paragraph based on one of the hypotheses formulated in the Discussion Points. The hypothesis is your topic sentence. The rest of the paragraph should support the hypothesis, that is, give reasons for your opinion. Finally, write a concluding statement that relates the significance of what you have written.

For example, suppose you state in your paper that students who have set their professional goals do better in school than those who have not. Your conclusion might be that schools should require students to state their major before they are admitted. Or you might suggest that this subject needs further research. Suppose your hypothesis is that students take drugs because of peer pressure. You might conclude that we need to change the attitude of young people toward drugs.

Be sure that your concluding statement answers *one* of these questions:

1. Why is your hypothesis important?
2. What effect will it have?
3. What can be done about it?
4. What should the reader do?

chapter 5

Defining

Energy

INTRODUCTION

When making a hypothesis or other statement, scientists must make sure they are understood by other researchers. Misunderstandings occur when there are different concepts of what is being discussed.

A definition answers the question, "What is it?" Sometimes a definition is necessary because a word or concept has more than one meaning. For example, whether carbon is a metal or nonmetal depends on how you define carbon. At other times, a definition is required because a term is being used in a special way. For example, physicists use the terms *work* and *energy* in ways that are more specific than their common meanings. A definition should be complete enough to include all the items in the category yet narrow enough to eliminate items that do not belong. The Greek philosopher Plato once defined man as a two-legged creature that has no feathers. His critic Diogenes left the room and brought back a bird without feathers, declaring, "Here is Plato's man!" The problem with Plato's definition was that it did not distinguish a man from other two-legged creatures without feathers. Communication between researchers is dependent on precise definitions of substances, concepts, processes, and ideas.

Short Reading

Read the following passage to find definitions for as many types of energy as you can.

The Many Forms of Energy

Energy is the ability to do work. When a hammer strikes a nail, it exerts a force on the nail that causes it to move. The movement of the hammer has the ability to do work and therefore has a form of energy that we call kinetic energy. Kinetic energy is the energy of motion.

An object may have energy not only because of its motion but also because of its position or shape. For example, when a watch spring is wound, it is storing energy. When this energy is released, it will do the work of moving the hands of the watch. This form of energy is called potential energy. Potential energy is stored energy. Water in a dam is another example of potential energy.

There are many types of kinetic and potential energy, including chemical, thermal, mechanical, electrical, and nuclear energy. Chemical energy is potential energy that is stored in gasoline, food, and oil. Just as the watch spring needs to be released to do the work of moving the hands, the energy stored in food molecules needs to be released by enzymes or substances in the body, and the energy stored in gasoline must be released by the spark plug to do its work of propelling the car forward. Thermal energy may be defined as the kinetic energy of molecules. When a substance is heated, the molecules move faster, which causes that substance to feel hot. Mechanical energy is energy related to the movement of objects. Electric energy is energy that is produced by electric charges. Nuclear energy is the energy that is stored in the nucleus of certain kinds of atoms, like uranium.

USING ENGLISH TO DEFINE

Aristotle suggested that a good definition should include the general classification of a term plus the specific characteristics that differentiate the term from other members of its class. For example, a definition of a giraffe should include a classification, such as, *A giraffe is an animal,* and specific characteristics, such as, *A giraffe is a tall, African animal with a very long neck.*

Definition formula:

Term = Class + Characteristics

Chemical energy is potential energy that is stored in gasoline, food, and oil. (Frequently, the characteristics appear as a relative clause beginning with *which, that, who,* or *where.*)

TERM		CLASS		CHARACTERISTICS
chemical energy	=	**potential energy**	+	**that is stored in gasoline, food, and oil**

Mechanical energy is energy related to the movement of objects. (The characteristics sometimes appear as a relative clause in which *which, that, who,* or *where* has been deleted.)

TERM		CLASS		CHARACTERISTICS
mechanical energy	=	**energy**	+	**(that is) related to the movement of objects**

Energy is the ability to do work. . . . Kinetic energy is the energy of motion. (Sometimes the characteristics take the form of an infinitive phrase or prepositional phrase.)

TERM		CLASS		CHARACTERISTICS
energy	=	**ability**	+	**to do work** (INFINITIVE PHRASE)
kinetic energy	=	**energy**	+	**of motion** (PREPOSITIONAL PHRASE)

Thermal energy may be defined as the kinetic energy of molecules.
(The use of the modal of possibility *may* indicates that there is more than one way to define something.)

TERM		CLASS		CHARACTERISTICS
thermal energy	=	**kinetic energy**	+	**of molecules**

Potential energy is stored energy.
(Sometimes the characteristics precede the class.)

TERM		CHARACTERISTIC		CLASS
potential energy	=	**stored**	+	**energy**

NOTE: When defining, remember the following:
1. Definitions require the present simple tense and the verb *to be*.
2. The definite article, *the*, is usually not used with the term being defined because definitions are general statements. For example, we would define *a* giraffe (in general), not *the* giraffe (a specific giraffe).

Sentence Patterns

DEFINING

TERM	=	GENERAL CLASS WORD	+	SPECIFIC CHARACTERISTICS
An astronomer	is	a scientist	who	studies the universe.
A barometer	is	an instrument	that	measures air pressure.
Conduction	is	a process	by which	heat is transferred.
A laboratory	is	a place	where	experiments are performed.
Physics	is	the study		of matter and energy.
A volt	is	a unit		for measuring electrical pressure.

TERM	=	SPECIFIC CHARACTERISTICS	+	GENERAL CLASS WORD
Mercury	is a	liquid		metal.
A triangle	is a	three-sided		plane figure.
Asbestos	is a	fire-resistant		mineral.
A dinosaur	is a	prehistoric		reptile.
A monkey	is a	small, long-tailed		primate.

Analyzing Definitions. In each of the following definitions, underline the general class once, and the specific characteristic(s) twice.

1. Helium is an inert gas that is light and nonflammable.
2. Protozoa are one-celled organisms.
3. A machine is a device that transforms energy from one form to another.
4. The cerebrum is the part of the brain that is the center of reasoning.
5. An insulator is a substance that does not conduct heat or electricity.
6. Fog is a cloud that forms on the ground.
7. Ecology is the study of the environment.
8. A satellite is a celestial body that orbits another celestial body.

Correcting Definitions. Listed in the box are some guidelines for writing good definitions and following are some poorly written definitions. Determine what is wrong with each definition and discuss how you would improve it.

- Identify the class. Examples, descriptions, or comparisons may be included in your definition, but they should not replace the class term.
- Be precise. Saying that "carbon dioxide is a gas" is not enough. What are the specific characteristics that differentiate it from other gases?
- Beware of circular definitions. A statement like "an agronomist is a person who practices agronomy" clarifies nothing.
- Make sure the definition is not more difficult than the term you are defining. A definition should clarify, not confuse.
- Use negative definitions like "a tomato is not a vegetable," when you think people have a wrong idea. But then follow it with a proper definition. Now that we know what it isn't, what is it?
- Be objective. Saying that "a pizza is something really good to eat" explains nothing to a Martian who has never seen a pizza.

1. A scientific theory is a theory like Darwin's theory.
2. An apple is round, red, and about the size of a fist.
3. Calculus is a tough subject.
4. An ear is an auditory appendage of *Homo sapiens* and other species.
5. A unicorn is not a real animal.
6. Tornadoes are very dangerous.
7. Radium is an element.

8. A compass looks like a clock.
9. An amphibian is like a frog or a turtle.
10. A supernova is a big nova.

Relative Clauses

A clause is a part of a sentence that contains a noun and a verb. A relative clause is one that begins with *which, that, where,* or *who. Which* and *that* are most commonly used in science definitions; *who* is used when referring to people. Science definitions often include relative clauses containing the characteristics that distinguish an item from others in the class.

Using Relative Clauses. Combine each of the following pairs of sentences to produce a one-sentence definition with a relative clause.

1. Protons are positively charged particles. They are contained in the nucleus of an atom.
   Protons are positively charged particles that are contained in the nucleus of an atom.
2. A black hole is an area in space. It has a gravitational pull so powerful that nothing, not even light, can escape.
3. Marine biologists are scientists. They study animals and plants that live in the sea.
4. The stratosphere is a portion of the atmosphere. It is over seven miles high.
5. Insulin is used in the treatment of diabetes. It is a hormone produced by the pancreas.
6. The most abundant form of life on earth are bacteria. They are simple forms of plant life.
7. Oxidation is a chemical reaction. It involves the loss of one or more electrons by an atom or ion.
8. Nitrogen makes up 80 percent of the air. It is a colorless, odorless gas.

Formulating Definitions. Using the information given in each series, write a definition. Use the sentence patterns at the beginning of this unit to guide you.

1. an amoeba / one-celled animal / constantly changes its shape
   An amoeba is a one-celled animal that constantly changes its shape.
2. an antibiotic / drug / cures bacterial diseases
3. lung / organ / breathing

4. acoustics / science / sound
5. photosynthesis / process / plants manufacture food
6. catalyst / substance / speeds up but is not changed by a chemical reaction
7. calorie / unit / measures heat
8. cyclotron / apparatus / bombards the nuclei of atoms

Creating Definitions. A good way to see if a definition is complete is to reverse it. For example, if we reverse *an elephant is an animal,* we get *an animal is an elephant,* and it is obvious that the definition is inadequate. Formulate a definition for each of the following words and test each one by reversing it. If you need help, use a dictionary.

1. a camera
2. a bridge
3. an x-ray
4. a butterfly
5. geology
6. a diamond
7. an echo
8. a virus
9. caffeine
10. an aquarium

An elephant is an animal with big ears and a trunk.

READING SKILLS

Vocabulary Building

One way to guess the meaning of a new word is to see if it is related to one you already know. For example, if you already know the meaning of *benefit,* you can guess that the word *beneficial* refers to something good. Related words also help you to remember a new word. For example, if you know that *toxic* means poisonous, it will be easy to remember that *intoxicated* means poisoned with drugs or alcohol. And if you know that the *horizon* is the line where the sky seems to meet the earth, you will remember that a *horizontal line* goes from side to side rather than up and down.

However, just as word parts can sometimes be misleading, related words can occasionally lead you astray. For example, although *infinite* means enormous or very large, *infinitesimal* means tiny or very small! The only way to guard against making mistakes is to see if the meaning you have guessed fits the sentence and paragraph.

Prefixes: **ecto-/exo-, endo-, micro-, macro-.** Study the following list of prefixes and then match the terms at the left below with their meanings at the right. You will not use all the meanings listed.

***ecto-* or *exo-*: outside**
***exogenous*—due to external causes**

***endo-*: inside**
***endogenous*—due to internal causes**

***micro-*: small**
***microscopic*—too small to be seen without a microscope**

***macro-*: large**
***macroscopic*—large enough to be seen with the naked eye**

__d__ 1. ectoplasm
_______ 2. endoplasm
_______ 3. microbe
_______ 4. microcosm
_______ 5. micrometer
_______ 6. microthermal
_______ 7. microsecond
_______ 8. macronucleus
_______ 9. macrocosm

a. the entire universe
b. a little universe
c. a minute period of time
d. external layer of protoplasm
e. internal layer of protoplasm
f. a very minute organism
g. relating to small quantities of heat
h. a large, dense nucleus
i. an instrument for measuring distances or angles
j. a minute cell

Vocabulary in Context. Circle the letter of the answer that best matches the meaning of the italicized word as it is used in each of these sentences.

1. Frayed electrical wires are *potential* fire hazards.
   (a.) probable   b. unlikely
2. The *velocity* of the wind increased during the storm.
   a. sound   b. speed
3. Despite the head-on collision, the engine remained *intact*.
   a. whole   b. broken
4. The *conservation* of natural resources, such as rivers and forests, is an important issue of our time.
   a. preservation   b. observation
5. When the temperature dropped, *vapor* accumulated on the inside of the window.
   a. steam   b. dust
6. Pasteur's germ theory proved to be *valid* and was a major breakthrough in the history of medicine.
   a. false   b. true
7. When the bottle was uncapped, all the pressure inside was *released*.
   a. set free   b. increased
8. Energy is released by the *fission* of atomic nuclei.
   a. splitting   b. combining
9. The cold on top of the mountain got more *intense* later in the evening.
   a. extreme   b. moderate
10. An alloy is a *fusion* of two or more metals that makes a stronger metal.
    a. combination   b. separation

Scanning

Scan the following passage in three minutes or less and put brackets around the following:

1. A definition of *work* (key words: work, defined)
2. The name of the French chemist who studied chemical changes in 1785 (key words: 1785, French—look for a capital *F*)
3. The meaning of the letter *c* in the equation $E = mc^2$ (key words: $E = mc^2$, the letter *c*)

Reading

$E = mc^2$

Energy can be transformed or changed from one type to another. For example, an apple hanging on a tree has potential energy, or the energy of position. As it falls, it loses potential energy because its height decreases. At the same time, it gains kinetic energy, or the energy of motion, because its velocity increases. Potential energy is being transformed into kinetic energy.

Frequently, the transfer of energy involves a transfer from one body to another. When you lift up a rock, you are changing the chemical energy of the food you have eaten into muscle energy. As you lift the rock high, your muscle energy is changing into the rock's potential energy.

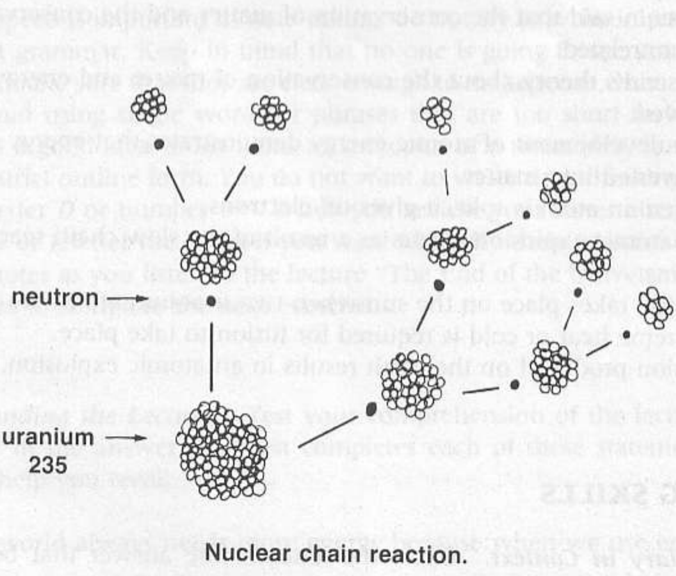
Muscle energy is transformed into mechanical energy.

When energy is transformed from one type to another or transferred from one body to another, no energy is lost. When we measure energy, we discover that the total amount remains intact. Suppose we prepared, cooked, and then ate some food. If we were to measure carefully all the energy that remains at the end of this process (such as potential, kinetic, and heat), we would always find exactly the same amount of energy as we started with (such as chemical and potential). Energy can thus be converted from one form to another but never created or destroyed. This is called the law of the conservation of energy.

Matter, like energy, can be converted from one form to another but neither be created nor destroyed. In 1785, the French chemist Antoine Lavoisier demonstrated that there is no gain or loss of mass in a chemical change. For example, when a piece of wood is burned, ashes remain. At the same time, the wood combines with oxygen in the air to form carbon dioxide and water vapor, which pass into the air. If the carbon dioxide, water vapor, and ashes are added together, the total weight will equal the original weight of the wood plus the oxygen in the air. Thus, there is no change in the total mass. This is called the law of the conservation of mass.

Many years later, Albert Einstein theorized that the conservation of energy is not distinct from the conservation of mass, that is, that there is a single law, the law of conservation of matter and energy. He predicted that matter could be changed into energy and vice versa. This concept was expressed in his famous equation $E = mc^2$, where E represents the amount of energy, m is the amount of matter, and c is a constant equal to the speed of light.

Einstein's theory proved to be valid in 1939, when it was discovered that enormous amounts of energy could be released by splitting uranium atoms, a process called fission. When a uranium or plutonium atom is split apart, it gives up neutrons that in turn split other atoms. This chain reaction takes place very rapidly and releases a huge amount of energy, resulting in the explosion of an atomic bomb.



Nuclear chain reaction.

Although it may seem strange, a process that is the exact opposite of fission can also release great quantities of energy. Under conditions of intense heat, such as are found at the center of the sun, hydrogen atoms combine to form helium atoms. The transformation of hydrogen into helium is called fusion. When fusion takes place, the hydrogen atoms lose a small amount of mass, which is transferred into energy. Fusion produced on the earth results in a hydrogen bomb, which is much more powerful than the original atomic bomb. But the principle of fusion can also be used to produce energy for peaceful purposes that can supply all of the needs of the human race for a long time.

Understanding the Reading. Each of the following statements is inconsistent with the information in the previous passage. Test your reading comprehension by finding the error in each statement and restating it correctly.

1. Energy can be transformed from one type to another, but it cannot be transferred from one body to another.

   Energy can be transformed from one type to another or transferred from one body to another.
2. Kinetic energy is the energy of position.
3. Unlike matter, energy cannot be created or destroyed.
4. Potential energy is when you lie in bed thinking of all the things you have to do.
5. Einstein said that the conservation of matter and the conservation of energy are unrelated.
6. Einstein's theory about the conservation of matter and energy was never proved.
7. The development of atomic energy demonstrates that energy can be converted into matter.
8. When an atom is split, it gives off electrons.
9. An atomic explosion occurs as a result of the slow chain reaction of splitting atoms.
10. Fusion takes place on the sun when two uranium atoms are combined.
11. Extreme heat or cold is required for fusion to take place.
12. Fusion produced on the earth results in an atomic explosion.

LISTENING SKILLS

Vocabulary in Context. Circle the letter of the answer that best matches the meaning of the italicized word as it is used in each of these sentences.

1. Scientists do not *assume* something is true until evidence confirms it.

   (a.) accept b. deny

2. It was once thought our natural resources were *inexhaustible*.
   a. limited b. endless
3. When we use energy, we *degrade* that energy to a less useful form.
   a. reduce b. improve
4. His sickness was *manifested* by pain and fever.
   a. indicated b. cured
5. Despite setbacks, they *proceeded* with the experiment.
   a. went forward b. went backward
6. Ice is water in its solid *state*.
   a. process b. condition
7. We could not find the papers because the laboratory was *in disorder*.
   a. organized b. disorganized
8. The condition of the patient has *degenerated* despite the operation.
   a. worsened b. improved
9. If fuel is not conserved, our resources may one day be *depleted*.
   a. used up b. saved

Note-Taking

Since speed is important in note-taking, do not try to write in perfect sentences or correct grammar. Keep in mind that no one is going to see your notes except you. Just make sure that they are clear enough to make sense when you read them later. Avoid using single words or phrases that are too short to be meaningful. Also, it is a good idea to list items as subtopics of a main idea, but do not try to follow a strict outline form. You do not want to waste time thinking, for example, "Is this letter *D* or number 5?" When you review your notes after class you can renumber or reletter the items if you want to clarify their relationship.

Take notes as you listen to the lecture "The End of the Universe" and then use your notes to complete the next exercise.

Understanding the Lecture. Test your comprehension of the lecture by circling the letter of the answer that best completes each of these statements. Use your notes to help you recall.

1. The world always needs more energy because when we use energy we ________ .
   a. destroy it (b.) change it to a less useful form
2. Energy always changes to a ________ .
   a. higher grade b. lower grade

3. All energy eventually winds up as ________ .
   a. muscle energy b. heat energy

4. When you rub your hands, muscle energy changes to ________ .
   a. heat energy b. kinetic energy

5. Energy always flows from ________ .
   a. hot to cold b. cold to hot

6. Natural processes move from ________ .
   a. order to disorder b. disorder to order

7. Perfume escaping into the air is an example of the change from ________ .
   a. order to disorder b. potential energy to kinetic energy

8. Everything in the universe will eventually be in a state of ________ .
   a. order b. disorder

Separate the salt and pepper?

9. We do not need to worry about the degeneration of the universe because it ________ .
   a. won't happen b. won't happen for a long time

10. The main idea of this lecture is that energy ________ .
    a. can't be destroyed b. runs downhill

DISCUSSION POINTS

Below are some nonscientific or "creative" definitions. They do not follow the formula for a scientific definition; instead, they are developed by the writer to express an opinion. For each of these creative definitions, tell what you think the writer meant and whether you agree with the writer.

1. Knowledge is the antidote to fear.—*Ralph Waldo Emerson*

2. Work consists of whatever a body is *obliged* to do, and play consists of whatever a body is not obliged to do.—*Mark Twain*
3. Genius is 1 percent inspiration, 99 percent perspiration.—*Thomas Alva Edison*
4. Art is I, Science is we.—*Claude Bernard*
5. Courage is resistance to fear, master of fear—not absence of fear.—*Mark Twain*
6. . . . Education means—to be able to do what you've never done before.—*George Herbert Palmer*
7. All life is an experiment. The more experiments you make the better.—*Ralph Waldo Emerson*
8. Knowledge is the knowing that we cannot know.—*Ralph Waldo Emerson*

WRITING SKILLS

Extended Definitions

A definition may consist of as little as a sentence or as much as a book. When a concept is too complex to be defined in one or two sentences, an extended definition is needed. An extended definition includes the basic parts of a formal definition (class + characteristics) as well as additional information that may include description, examples, classification, comparison, explanation, or other details. For example, an extended definition of a natural phenomenon (such as an eclipse, earthquake, or hurricane) would probably include causes and effects. An extended definition of a machine would probably include its functions and uses. An extended definition of a celestial object (such as a planet or comet) might include its location in respect to the earth and a comparison with another heavenly object. An extended definition of a disease would probably include its symptoms, prevention, and cure. An extended definition of an element or chemical would include where it occurs in nature and its chemical and physical properties.

Writing an Extended Definition

Write a paragraph giving an extended definition of a simple instrument or device such as a compass, fever thermometer, electric fan, pencil sharpener, flashlight, calculator, or toaster. Your topic sentence should be a formal definition, that is, the class plus distinguishing characteristics:

A thermometer is a device for measuring temperature.

A flashlight is a portable light that works on batteries.

The rest of the paragraph should include additional characteristics such as:

1. A description of its appearance, such as its shape, size and color;
2. A description of what it is made of; and
3. An explanation of its principle of operation or how it works.

A good way to conclude this type of definition is to describe its uses.

chapter 6

Exemplifying

Heat

INTRODUCTION

After giving a definition or making any general statement, the best way to clarify a point is to give an example of it. A Chinese proverb says that a picture is worth a thousand words. It might also be said that one example is worth a thousand explanations. An example brings the general or abstract statement down to a specific or concrete image. For example, it is one thing to say that smoking is bad for your health and another to say that a regular smoker loses about five and a half minutes of life expectancy for each cigarette smoked. The example adds impact, making the statement more memorable, more interesting, and more persuasive, as well as providing evidence for it.

Scientists use examples to explain or clarify a concept and to give evidence to support it. Examples can sometimes serve to test the validity of a point. If no example can be found to illustrate a point, there may not be a point.

Short Reading

Read the passage below and underline examples of how heat affects the properties of matter.

The Effects of Temperature

Temperature affects matter in many ways. As a substance gets hotter, its molecules move faster and its properties are altered. The physical state of a substance is affected by its temperature. For example, at a temperature of 0° C or below, water is a solid (ice); above 0° C it becomes a liquid; and at 100° C it turns to a gas (steam). Almost all other substances are similarly affected by temperature.

Temperature alters the color of matter. Iron, for example, turns red, then orange, and then white at increasingly high temperatures. (You have seen the iron burner on a stove turn red.) An incandescent light bulb provides another example of a color change, for its tungsten wire gives off a white light when it is hot.

The size of an object is affected by temperature. Most materials expand when they are heated and contract when they are cooled. A glass may break when boiling water is poured into it because part of the glass heats up and expands more rapidly than the rest.

Temperature also affects the pressure of a gas. As a gas is heated, its molecules begin to move rapidly, colliding with the walls of the container. If a closed glass tube is heated, the increased pressure inside will cause it to break.

The ability of a metal to resist electricity varies with its temperature. The increased movement of its molecules makes the molecules less resistant to electrical charge. Heated wires cause excess electrical movement, which can damage machines. Computers and other sensitive machines function best in air-conditioned rooms.

Living things are very sensitive to comparatively small temperature changes. This is exemplified when we touch something very hot or cold and feel pain. The pain serves to protect us, because living things cannot stand extremes of temperature. Using the same principle, we pasteurize milk and cook meat to kill harmful bacteria and other organisms that cannot tolerate the heat.

USING ENGLISH TO EXEMPLIFY

The above passage makes several claims about how temperature affects matter. Each statement is followed by specific examples that serve to illustrate the point.

The physical state of a substance is affected by its temperature.

(Examples make a point clearer and at the same time, give evidence to support it.)

For example, at a temperature of 0° C or below, water is a solid. . . .

Temperature alters the color of matter.
(An example may comprise a few words, a sentence, a paragraph or more.)

Iron, for example, turns red, then orange, and then white at increasingly higher temperatures.

The size of an object is affected by temperature.
(Examples are not always marked with clue words such as *for example*, *for instance*, and *to illustrate*, and often can only be identified by the context of the paragraph.)

A glass may break when boiling water is poured into it. . . .

Temperature also affects the pressure of a gas.

If a closed glass tube is heated, the increased pressure inside will cause it to break.

The ability of a metal to resist electricity varies with its temperature.

Heated wires cause excess electrical movement, which can damage machines.

Living things are very sensitive to comparatively small temperature changes.
(Sometimes more than one example is used to explain the various aspects of a concept.)

This is exemplified when we touch something very hot or cold and feel pain.

. . . We pasteurize milk and cook meat to kill harmful bacteria and other organisms that cannot tolerate heat.

Sentence Patterns

EXEMPLIFYING

For example, / For instance, / To be specific, / To illustrate, } iron turns red when it is heated.

Iron, {for example, / for instance,} turns red when heated.

Iron is {an example / a case / an instance / an illustration} of a substance that turns red when heated.

Iron {exemplifies / illustrates} the concept of heat affecting color.

The concept of heat affecting color is {exemplified / illustrated} by iron.

Solids {such as / like} iron and copper turn red when heated.

NOTE: When writing examples, remember the following:

1. *Examples in science are usually written in the present simple tense.*
2. *Examples are also used to illustrate terms, and these examples are similar to classification. For instance, the sentence,* Copper is an example of a metal, *is both an example and a classification. If all possible examples of a term are given, it is more classification than example.*
3. *Examples are* not *always marked with clue words and often can only be identified by the context of the paragraph.*

Analyzing Exemplification. In each of these pairs or groups of sentences, underline the general statements once and the examples twice.

1. Carbohydrates are organic compounds. Organic compounds contain carbon in combination with hydrogen and oxygen.
2. Some birds travel enormous distances without resting. The ruddy turnstone flies nonstop from Alaska to Hawaii every year.

3. Parasites are living things that feed off other living things. The mistletoe plant lives off apple, maple, and poplar trees, causing them to die from malnutrition.
4. Several theories have been proposed to explain the nature of light. Christian Huygens suggested that light travels in waves. Albert Einstein proposed that light is transmitted as tiny particles, or photons.
5. Symbiosis is the coexistence of living things for their mutual benefit. Plant lice or aphids live with ants in a symbiotic relationship.
6. Atomic research has led to the development of artificially prepared elements. Einsteinium, fermium, californium, and berkelium are all manmade elements.

Recognizing Examples. Each of these general statements is followed by three sentences. In each case, circle the letter(s) of the sentence(s) that best support the general statement. One, two, or three sentences may be circled.

1. There is little possibility that there is life on any other planet within our solar system.
   a. Mercury and Venus are too hot to support life.
   b. There are only nine planets in our solar system.
   c. Uranus, Neptune, and Pluto are extremely cold and dark.
2. Vitamins may be harmful in excessive doses.
   a. Vitamin C can be taken in large doses without harm.
   b. Excessive amounts of Vitamin A may increase susceptibility to disease.
   c. Vitamin D prevents the disease rickets.
3. Temperature may be measured by different types of thermometers.
   a. The Celsius and Fahrenheit thermometers measure relative temperature.
   b. A barometer measures atmospheric pressure.
   c. A Kelvin thermometer measures absolute temperature.
4. A machine is a device that transforms energy from one form to another.
   a. A car engine converts the chemical energy of gasoline into mechanical energy.
   b. The food we eat is converted into energy in our bodies.
   c. A generator or dynamo changes mechanical energy into electrical energy.
5. Energy has many forms.
   a. Nuclear energy comes from splitting the nucleus of uranium or plutonium atoms.
   b. Radiant energy comes in the form of sunlight, x-rays, or gamma rays.
   c. Energy may be converted from one form to another.

Modals of Necessity

In Chapter 4 you saw how modals are used to express probability. English modals are also used to express necessity. The modals of necessity are *must,** *have to, should,* and *ought to.*

In scientific writing, these modals are used in special ways. *Should* and *must* appear most frequently, usually in the passive voice. *Must* expresses a very strong need. It implies that anything else is impossible.

A speed of 18,000 miles per hour *must be maintained* for the satellite to remain in orbit.

Should is more moderate than *must* and sometimes expresses a recommendation.

This crop *should be watered* every day during the dry season.

However, in technical instructions, particularly for warnings, *should* is frequently used to mean *must.*

All nonessential personnel *should be evacuated* from the area of the explosion.
All nonessential personnel *must be evacuated* from the area of the explosion.

These two sentences have the same meaning.

Using Modals of Necessity. To each of the following sentences, add *must* and use the passive form of the verb in parentheses.

1. X-rays <u>must only be administered</u> (only administer) when necessary.
2. Hydrochloric acid ______________________ (prepare) by heating sodium chloride with concentrated sulfuric acid.
3. For the body to combat germs, white blood cells ______________________ (produce) in the body.
4. The generator ______________________ (always turn off) before an inspection.
5. The vapors of carbon tetrachloride are poisonous and ______________________ (not inhale).

**Must* is also used to express strong probability. For example, *There must be a leak in this valve.*

6. For human life to begin, an egg cell in the female ______________________ ______________________ (fertilize) by a sperm.
7. Potassium ______________________________________ (never allow) to come in contact with water.
8. The facepiece seal on an oxygen breathing apparatus ______________________ ______________________ (never release) in an unsafe atmosphere, even if inhalation becomes difficult.

Formulating Sentences with Necessity. Formulate sentences using *should* in the passive voice, following the pattern of the first pair of sentences, below.

1. The electricity is not shut off.
   The electricity should be shut off.
2. The blood donors are not being tested for anemia.
3. The radiation monitoring devices are not being calibrated regularly.
4. A fire extinguisher is not available in the laboratory.
5. The explosive devices are not properly insulated.
6. The technicians are not being protected from excessive radiation.
7. The needles are not being sterilized before the injections.
8. The patients are not being immunized against the flu.

READING SKILLS

Vocabulary Building

Knowing whether a word is a noun, verb, adjective, or adverb will sometimes help you guess its meaning. For example, in the sentence, *The whale surfaced from time to time to breathe air,* you can figure out that the word *surfaced* is a verb in the past tense because it follows the subject (*whale*) and has an *-ed* ending. Then, the phrase *to breathe air* will give you the clue that *surfaced* means *came to the top*. In the sentence, *The moon revolves around the earth,* you could assume that *revolves* is an action, since it appears in the position of the verb. (The prepositional phrase *around the earth* gives you a further clue to its meaning.)

Suffixes are word endings like *-ed*, *-ly*, or *-ing*. They frequently offer clues to the word's part of speech. For example, you already know that the suffix *-ed* is used for verbs in the simple past tense and that the suffix *-ly* can be added to many adjectives (such as *soft* or *careful*) to make them adverbs (*softly, carefully*).

Suffixes: **-en, -ify, -cation**. From the adjective *hard,* we can make the verb *to harden,* which means to make something hard. Convert each of these nouns and adjectives to verbs, using the suffix *-en*. If the word ends in *-e,* just add *-n*.

1. short *shorten*	9. tight ______
2. broad ______	10. loose ______
3. deep ______	11. bright ______
4. dark ______	12. fright ______
5. wide ______	13. strength ______
6. weak ______	14. length ______
7. soft ______	15. sharp ______
8. black ______	16. straight ______

Some verbs are formed with the suffix *-ify*. Write the appropriate form of the verb in the following spaces. The words with asterisks require some change in spelling. If necessary, check your dictionary.

1. to find the identity* *to identify*
2. to make solid ______
3. to make liquid* ______
4. to make pure* ______
5. to give an example* ______
6. to make humid ______
7. to charge with electricity* ______
8. to make clear* ______

The suffix *-cation* indicates a noun. Convert each of the *-ify* verbs above into a noun by changing the *y* to *i* and adding *-cation*.

1. *identification*
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______
8. ______

Vocabulary in Context. Circle the letter of the answer that best matches the meaning of the italicized word as it is used in each of these sentences.

1. To open the door, first *insert* the key in the lock.
   a. turn　　(b.) enter
2. The submarine was completely *submerged* in the water and could not be seen.
   a. sunk　　b. uncovered
3. Sound cannot be *conducted* in a vacuum because there are no air waves to transmit it.
   a. carried　　b. absorbed
4. Wires were *insulated* to prevent the transfer of electricity or heat.
   a. covered　　b. exposed
5. *Fluids* are not rigid and can flow from one container to another.
   a. solids　　b. liquids and gases
6. Germs are *invisible* without the aid of a microscope.
   a. unable to be seen　　b. unable to be divided
7. After the fire, the nuclear reactor was *emitting* radiation.
   a. giving off　　b. absorbing
8. The sun *radiates* heat and light.
   a. takes in　　b. gives off
9. When there is a *disparity* between test results, the test should be repeated.
   a. similarity　　b. difference

Scanning

Scan the following passage in three minutes or less and put brackets around the following:

1. One example of conduction,
2. one example of convection, and
3. one example of radiation.

Keep in mind that examples usually come directly after definitions or general statements.

Reading

How Heat Is Transferred

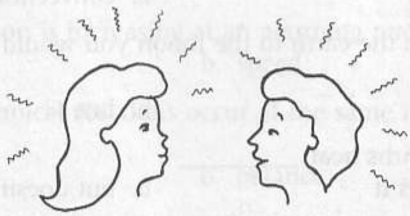
Heat is the energy that warms our houses and cooks our food. It is the transfer of energy from a warmer body to a cooler body. How does this heat transfer take place?

Conduction is one method of heat transfer that takes place when there is a difference in temperature between two objects. For example, if a silver spoon is inserted into a pot of hot tea, the handle of the spoon will immediately become hot. This is because the molecules at the submerged end speed up, which causes the slow-moving molecules at the cold end to move faster. Energy is thus transferred or conducted.

Heat flows from a warmer object to a cooler one until the temperatures are equal. Substances like metals are good conductors because heat transfers readily from one molecule to another. All substances conduct some heat, but substances like glass, plastic, and wood act as insulators because their molecules transfer energy so slowly. Gases and liquids are poor conductors because the molecules make very little contact with which to pass on the energy. The warmest materials are those that trap pockets of air, such as wool, fiberglass, asbestos, and down. A vacuum would make an ideal insulator because it has no molecules to transfer the heat.

Although molecules in a fluid do not conduct heat very well, they do transfer heat by convection. Convection is the upward flow of masses of liquid or gas molecules as they are heated from below. The hot air rising above a radiator is an example of convection. As the heat causes the air to expand, it becomes less dense and rises. Convection is used in hot air furnaces, in which air is heated and then forced into a room to replace the cold air, which is then drawn into the furnace to be heated. Winds and ocean currents are examples of convection found in nature.

Radiation is the third method of heat transfer. All life on earth is dependent on the radiation of the sun's heat and light energy. One fascinating aspect of the sun's radiation is that the electromagnetic rays that carry warmth and light to the earth are themselves invisible and without heat. We know this because the space between the earth and the sun is dark and cold, but when the rays reach the earth, they light the atmosphere and warm our world. In contrast to conducted and convected heat, radiated heat passes through a vacuum.



All things give off radiation.

All objects emit, or give off, radiation. For example, when two objects are near each other, the one that is warmer will give off more energy than the cooler one, thus transferring energy from one to the other. Usually, objects do not absorb all the energy but reflect some of it. Light colors reflect more energy than dark colors. Highly polished surfaces reflect more energy than dull ones.

The three modes of heat transfer—conduction, convection, and radiation—are subject to two conditions: First, heat is transferred only when there is a disparity in temperature, and second, the flow is always from hot to cold.

Drawing Conclusions. A scientist must be able to draw conclusions from the available facts. For example, if it is true that wood is a better insulator than metal, it is a logical conclusion that wood would make a better pot handle than metal.

After reading the previous passage carefully, indicate what conclusions can be drawn from the information it contains by circling the letter of the answer that best completes each of these sentences.

1. If the molecules in your tea are moving very rapidly, your tea is ________ .
   a. hot b. cold
2. Opening the door between a warm room and a cold one will cause the temperature in the two rooms to ________ .
   a. equalize b. increase
3. Oxygen is a ________ conductor of heat.
   a. good b. poor
4. A double-glass window that traps air is a ________ insulator.
   a. good b. poor
5. Since cork has air pockets, it is a ________ insulator.
   a. good b. poor
6. An air conditioner that causes hot air to rise operates on the principle of ________ .
   a. conduction b. convection
7. On a trip from the earth to the moon you would pass through ________ temperatures.
   a. cold b. hot
8. The earth absorbs heat ________ .
   a. and radiates it b. but doesn't radiate it
9. The most comfortable clothing on a hot, sunny day is ________ .
   a. light colored b. dark colored
10. A house with white walls will be ________ than one with dark walls.
   a. cooler b. warmer

LISTENING SKILLS

Vocabulary in Context. Circle the letter of the answer that best matches the meaning of the italicized word as it is used in each of these sentences.

1. The *subtraction* of all the air created a vacuum.
   a. addition b. removal
2. The *conversion* of a wormlike caterpillar into a beautiful butterfly is fascinating to watch.
   a. transformation b. separation
3. The climate of the earth may be *gradually* becoming warmer.
   a. slowly b. rapidly
4. There is *sufficient* gasoline in the car to make the trip but not to return.
   a. high quality b. enough
5. A liquid will *solidify* if cooled enough.
   a. melt b. harden
6. Perfume will *evaporate* quickly from an open bottle.
   a. vaporize b. liquefy
7. The wind *dispersed* the leaves all over the field.
   a. gathered b. scattered
8. Ammonia must be kept in a container with a tightly closed lid because it *is volatile.*
   a. evaporates b. liquefies
9. A desert climate is characterized by a lack of *moisture* in the air.
   a. wetness b. dryness
10. The world population is increasing at an alarming *rate.*
    a. place b. speed
11. When opposite chemical reactions occur at the same rate, a state of *equilibrium* exists.
    a. disorder b. balance
12. The ratio of hydrogen to oxygen in water is *constant.*
    a. changing b. unchanging

Note-Taking

When taking notes during a lecture, concentrate on the main ideas. However, if you have time, also write down additional details such as examples. As in written material, examples in a lecture usually come directly after the points they illustrate. Examples will help you understand and remember any point that is difficult or unfamiliar. They can also be used to prove or substantiate your point when writing an answer to an essay question.

Take notes as you listen to the lecture "The Changing State of Matter" and then use your notes to complete the next exercise.

Understanding the Lecture. Indicate whether each of the following statements is true (*T*) or false (*F*) according to the information in the lecture.

T 1. A change of state cannot occur without adding or subtracting heat.

_______ 2. Only a few substances can convert from one physical state to another.

_______ 3. The conversion of a solid to a liquid is called evaporation.

_______ 4. All substances melt at the same temperature.

_______ 5. Gases such as oxygen cannot be solidified.

_______ 6. Heating a liquid causes the molecules to move faster.

_______ 7. Fog is an example of evaporation.

_______ 8. A volatile substance is one that is stable.

_______ 9. Alcohol is a volatile liquid.

_______ 10. The condensation point is the same as the boiling point.

_______ 11. Equilibrium exists when the rate of condensation and the rate of evaporation are the same.

_______ 12. Clouds are formed by the process of evaporation.

DISCUSSION POINTS

Give one or two examples of each of the following. Explain your answers.

1. Scientific facts that still amaze you.
2. Machines you would not want to live without.
3. Machines you wish had never been invented.
4. Scientific discoveries you would like to have witnessed.
5. Things you would like someone to invent.
6. Places you would like to explore.
7. Things you think scientists will never know.

WRITING SKILLS

Exemplifying

Exemplifying is one of the most useful ways of explaining or clarifying a point. Broad, general statements are frequently neither interesting nor persuasive. Examples help the reader move from the abstract to the concrete level and thus visualize the writer's point. In scientific writing in particular examples help establish the credibility of a statement. If you are making an argument, examples will help convince your readers. Finally, examples are the element of your writing most *likely to remain in your reader's mind. Consider the following:*

> Almost all embryonic animals have extensive regenerative capacities. Some animals retain these capacities after they reach maturity, while others lose them. An adult sea star or hydra can be chopped into many pieces and each piece can regenerate all necessary parts to become a whole individual. Half a planarian can regenerate the other half. Salamanders and lizards can regenerate new tails. But adult birds and mammals cannot regenerate whole new organs; regeneration in these animals is mostly limited to the healing of wounds.
>
> William T. Keeton,
> *Elements of Biological Science*
> (New York: W. W. Norton & Co., 1973), p. 349

Notice how the examples make the topic sentence clear and memorable. In fact, the examples enable readers to understand the topic sentence even if they do not know the meaning of *regenerative capacity* or *embryonic animals*.

Writing a Paragraph with Examples

Write a paragraph on one of the Discussion Points. Begin with a topic sentence and then support it with examples. Transition words for introducing examples include *for example, for instance, to illustrate, such as,* and *like*. Be sure to give an example to illustrate every aspect of your idea. For example, if you state that there are things we will never know about the universe, humans beings, the past, and the future, give examples of some of these things we will never know. If you give several examples to support one idea, arrange them in order of increasing importance. This will make your writing more forceful because your strongest example will be in the part of the paragraph that has the most emphasis or impact.

chapter 7

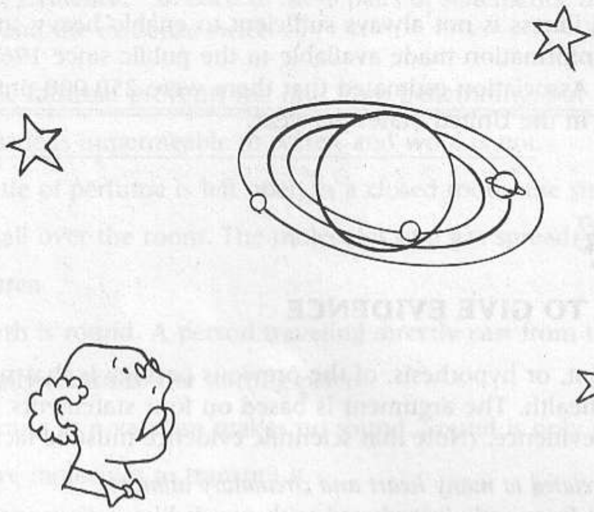
Giving Evidence

Smoking, Drugs, and Alcohol

INTRODUCTION

Once a hypothesis has been proposed, the question is always asked, "Where is the evidence?" The British scientist Sir Humphry Davy once burned diamonds into graphite, ignoring the expense, to demonstrate that diamonds and graphite are both crystallized carbon. He made his point.

Proof or evidence is usually the result of observation or experimentation, combined with reasoning. The theories that are accepted are those with the most supporting evidence. In the second century, Claudius Ptolemy proposed that the planets and the sun revolved around the earth. His theory was accepted because it predicted the position of the planets with some accuracy. But all "proofs" are tentative, to be discarded when another theory emerges that explains more facts. Thirteen centuries later, the Polish scientist Nicolaus Copernicus "proved" that the planets revolve around the sun by demonstrating that his theory explained things that Ptolemy's theory could not, like the seasons of the earth and the retrograde or backward motion of the planets. Then, in 1905 Albert Einstein shook everyone up by saying that motion is relative and that whether the sun is moving or the earth is moving depends on your point of view! And on and on we go, always striving to get closer and closer to the truth. But scientific theories can seldom be proven beyond a doubt. After all, no one can stand far enough out in space to observe the planets revolving around the sun!



Short Reading

Read the following passage to discover evidence that smoking is harmful.

Where There's Smoke, There's Fire

It was not too long ago that smoking by adults was not viewed as dangerous. Its long-term effects were not visible and had not been conclusively demonstrated. Then, in 1964 the Surgeon General of the United States announced that smoking had been proven by scientific research to be detrimental, or harmful, to health.

Since then, more and more evidence has accumulated to indicate that smoking is harmful. Smoking is related to many heart and circulatory ailments. The tobacco plant contains nicotine, a chemical that is poison in its pure form. It has been demonstrated that nicotine increases the rate of the heart, intensifies the effects of high blood pressure, and causes the constriction or tightening of the blood vessels, thus contributing to heart disease.

Smoking is the most significant factor in respiratory diseases. It can damage the tiny hairs (cilia) that line the breathing passages, thereby causing emphysema or chronic bronchitis. Research also confirms that the tar in cigarette smoke is carcinogenic, that is, it can produce cancer in any tissues it comes in contact with, such as the mouth, the throat, and the lungs.

There is also a correlation between smoking and birth defects. The evidence indicates that pregnant women who smoke a pack of cigarettes a day have a greater likelihood of having a miscarriage, a premature baby, a smaller-than-normal baby, or a baby with mental retardation or heart defects.

Smokers often become physically and psychologically dependent on their habit and suffer withdrawal symptoms if they attempt to stop. Even the onset of a smoking-related illness is not always sufficient to enable heavy smokers to quit. Despite all the information made available to the public since 1964, in 1985 the American Lung Association estimated that there were 250,000 premature deaths due to smoking in the United States per year.

USING ENGLISH TO GIVE EVIDENCE

The main point, or hypothesis, of the previous passage is that smoking is dangerous to your health. The argument is based on four statements, each of which is supported by evidence. (Note that scientific evidence must be fact, *not* opinion.)

Smoking is related to many heart and circulatory ailments.
(Evidence is frequently introduced with words like *indicates* or *demonstrates* rather than the stronger word *proves*. This reflects the "unprovable" nature of most scientific hypotheses.)

It has been demonstrated that nicotine increases the rate of the heart. . . .

Smoking is the most significant factor in respiratory diseases.

It can damage the tiny hairs (cilia) that line the breathing passages. . . .

Research also confirms that the tar in cigarette smoke is carcinogenic. . . .

There is also a correlation between smoking and birth defects.

The evidence indicates that pregnant women who smoke a pack of cigarettes a day have a greater likelihood of having a miscarriage. . . .

Smokers often become physically and psychologically dependent on their habit. . . .
(Evidence is not always marked with a clue word and often can only be identified by the context of the paragraph.)

Smokers often . . . suffer withdrawal symptoms if they attempt to stop.

Even the onset of a smoking-related illness is not always sufficient to enable heavy smokers to quit.

Identifying Evidence. In each of these pairs of statements, underline the conclusion once and the evidence twice.

1. A plastic raincoat prevents the rain from penetrating, but a wool coat does not. Plastic is impermeable to water, and wool is not.
2. If a bottle of perfume is left open in a closed room, the smell will eventually spread all over the room. The molecules of a gas spread, or diffuse, to fill the entire area.
3. The earth is round. A person traveling directly east from the equator will eventually return to the starting place.
4. A bell rung in a vacuum makes no sound. Sound is only produced when there are molecules to transmit it.
5. Life as we know it cannot exist on Venus. There is no oxygen or water on Venus.
6. Morphine is addictive. Hospital patients who are given morphine as a pain reliever sometimes develop a physical dependence on the drug.
7. Death often occurs when drugs and alcohol are used together. Certain combinations of alcohol and drugs can be fatal.
8. Glass is fragile, or breakable. A glass bottle dropped on a hard surface is likely to break.

Drawing Conclusions from Evidence. Circle the letter of the conclusion that can be drawn from each of these statements of evidence.

1. When the water in a closed bottle is heated, the water rises.
   a. Water evaporates when heated.
   b. Water expands when heated.
2. The shapes of the earth's continents fit together like pieces of a big jigsaw puzzle.
   a. The continents were once one land mass that broke into parts that drifted apart.
   b. The earth is expanding just as the universe is.
3. There is a high statistical correlation between smoking and emphysema.
   a. Emphysema patients like to smoke.
   b. Smoking is a cause of emphysema.

4. The space between the sun and the earth is cold.
   a. The sun is not as hot as it used to be.
   b. The rays of the sun warm what they touch but are not hot themselves.
5. In a crowded room, carbon dioxide gradually replaces the oxygen in the air.
   a. Human beings inhale oxygen and exhale carbon dioxide.
   b. Human beings inhale carbon dioxide and exhale oxygen.
6. When a bean seed is grown in the dark, the plant soon dies.
   a. Bean plants need light to survive.
   b. Bean plants need light to turn green.
7. Alcohol can blur your vision.
   a. Alcohol affects driving ability.
   b. Alcohol does not affect driving ability.

Evaluating Evidence. After each of the following propositions, several statements are given. Circle the letters of those statements that give evidence or support for the proposition. There may be more than one answer for each.

1. Alcohol is dangerous for drivers.
   a. Alcohol is addictive.
   b. Alcoholics build up a tolerance for increasing amounts of alcohol.
   (c.) Alcohol impairs judgment.
   (d.) Many automobile accidents are alcohol related.
2. Aluminum is a light metal.
   a. Aluminum is produced from bauxite.
   b. Aluminum is one of the most abundant elements.
   c. Aluminum weighs less than iron, zinc, silver, gold, and copper.
   d. The melting point of aluminum is 660° C.
3. Water expands when it freezes.
   a. Water pipes sometimes crack in very cold weather.
   b. Water freezes at 0° C.
   c. Different substances freeze at different temperatures.
   d. Most substances contract when frozen.
4. Oxygen supports combustion.
   a. Blowing on a fire makes it burn more brightly.
   b. Forest fires are worse in a strong wind.
   c. Nitrogen does not support combustion.
   d. Smothering a fire will put it out.
5. Vitamin A is essential for a healthy diet.
   a. Lack of vitamin A may cause night blindness.
   b. Vitamin A is found in butter, eggs, and fish liver oils.
   c. Vitamin A aids the cells in fighting infection.
   d. An overdose of vitamin A can be toxic.

6. When water vapor comes in contact with a cold surface, it condenses or forms droplets of water.
   a. Eyeglasses cloud up when you enter a warm room from the cold.
   b. Raindrops formulate when clouds meet cold air.
   c. Dew forms on grass overnight.
   d. Rain turns to snow when the temperature drops below 0° C.

Deductive and Inductive Reasoning

Scientists use two basic methods to move from evidence to a conclusion: deductive reasoning and inductive reasoning. Deductive reasoning moves from a general premise or assumption to a specific conclusion. For example:

All metals are good conductors of electricity.
Zinc is a metal.
Therefore, zinc is a good conductor of electricity.

In contrast, inductive reasoning moves from a specific observation to a general conclusion. For example, if air is observed to expand or contract to fill any container, the assumption might be made that all gases behave this way. As a matter of fact, they do.

Deductive reasoning is always valid, that is, if it is properly stated and if the premises are true, the conclusion will be true. The conclusion is contained in the premises. By contrast, inductive reasoning can lead to false conclusions. For example, we might assume that if a particular mushroom is poisonous, all mushrooms must be poisonous. That would be a false assumption. Nevertheless, inductive reasoning can be very valuable in alerting the scientist to potential principles that must then be tested before they can be accepted.

Identifying Deductive and Inductive Reasoning. Indicate whether each of the following statements illustrates deductive (*D*) or inductive (*I*) reasoning.

__I__ 1. Iron silicates are green, iron carbonates are yellow-brown, and iron oxides are red. All iron compounds are colorful.

______ 2. Smoke causes cancer in rats. Smoke causes cancer in all living things.

______ 3. Tigers, horses, and dogs have tails. All four-legged animals have tails.

______ 4. Carbohydrates convert starch into sugar in the body. Potatoes are carbohydrates. Potatoes convert starch into sugar.

______ 5. Penicillin stops the growth of bacteria. Pneumonia is caused by bacteria. Penicillin is effective against pneumonia.

_______ 6. AIDS is a venereal disease. It is sometimes transmitted by blood. All venereal diseases may be transmitted by blood.

_______ 7. Halley's Comet passed near the earth in 1758, 1834, 1910, and 1986. Halley's Comet will return to the earth in the year 2062.

_______ 8. Automobiles give off carbon monoxide. Carbon monoxide is a poisonous gas. Therefore automobiles cause air pollution.

Using Reasoning. Deductive reasoning can sometimes lead to false conclusions. Here are two examples:

All students are lazy.
Everyone here is a student.
Therefore, everyone here is lazy.

All gases can flow.
All liquids can flow.
Therefore, all gases are liquids.

How did we arrive at such ridiculous conclusions? In the first example the original premise is false. False premises lead to false conclusions. In the second example, the conclusion does not follow from the premises, for although gases and liquids share one characteristic (both can flow), this does not mean they are the same in other ways.

Inductive reasoning can also lead to false conclusions. Sometimes there are not enough examples. Sometimes the examples are not representative or not typical. And sometimes the conclusion does not follow from the evidence.

In each of the following, discuss why the conclusion is false.

1. If it is a bird, it can fly.
   A chicken cannot fly.
   Therefore, a chicken is not a bird.
2. Einstein was not a good student.
   Einstein was a genius.
   Therefore, anyone who is not a good student is a genius.
3. All metals are solid.
   Sulfur is a solid.
   Therefore, sulfur is a metal.
4. People, kangaroos, penguins, and ostriches all walk on two feet.
   Therefore, they are members of the same species.
5. Archimedes discovered the principle of water displacement in the bathtub.
   The displacement principle is a major scientific discovery.
   Therefore, the place to make a major scientific discovery is in the bathtub.
6. Some elements are gases, and others are liquids.
   Sulfur is an element, and it is not a gas.
   Therefore, sulfur is a liquid.

7. Oak wood is lighter than water.
   Therefore, solids are lighter than liquids.
8. Either Galileo was a genius or he worked hard.
   Galileo was a genius.
   Therefore, Galileo did not work hard.
9. Marijuana has not been proven to be harmful.
   Therefore, marijuana is not a dangerous drug.
10. If it is an animal, it has a tail.
    A comet has a tail.
    Therefore, a comet is an animal.

READING SKILLS

Vocabulary Building

A synonym is a word that means the same as another word. Replace each italicized word in the following paragraph with a synonym from the list below. You will not use all the words listed.

insufficient	tolerance	stimulates
convince	irritability	deter
doses	detrimental	fatigued
calms	alert	beneficial

According to legend, coffee was discovered by a monk in the Middle Ages who noticed how frisky his goats were after they had eaten berries from a coffee tree. Coffee contains caffeine, a substance that *excites* the nervous system. Moderate *portions* of caffeine make the user feel less *tired* and more *awake*. High doses can be *harmful*, causing *excitability*. It is possible to increase *endurance* for caffeine so that higher doses are needed to produce the same effect. In certain places of the Middle East, there were times when coffee drinking was punishable by death, which probably was *not enough* to *persuade* some people to give up their morning cup.

Suffixes: **-ion, -or**. Change the following verbs to nouns by adding the suffix *-ion*. Drop the final *-e* if it exists. Words with an asterisk require a spelling change. Check your dictionary if necessary.

1. to connect *connection* __________
2. to conduct __________
3. to radiate __________
4. to insulate __________

5. to accelerate ______
6. to gravitate ______
7. to lubricate ______
8. to calculate ______
9. to eliminate ______
10. to attract ______
11. to absorb* ______
12. to correlate ______
13. to exert ______
14. to speculate ______
15. to extend* ______
16. to demonstrate ______
17. to formulate ______

Change the following verbs to nouns by adding the suffix *-or*. Drop the final *-e* if it exists.

1. to connect connector
2. to radiate ______
3. to insulate ______
4. to resist ______
5. to accelerate ______
6. to demonstrate ______
7. to correlate ______
8. to speculate ______
9. to lubricate ______
10. to calculate ______

Vocabulary in Context. Circle the letter of the answer that best matches the meaning of the italicized word as it is used in each of these sentences.

1. The drought *altered* conditions for the farmers.
   a. improved   (b.) changed

2. Cigarette smoking is so *addictive*, that many people cannot give it up.
   a. habit forming b. unhealthy

3. She was lonely and suffered from *depression*.
   a. sadness b. disease

4. Aspirin will frequently *relieve* pain for a few hours.
   a. ease b. worsen

5. Poor physical condition will make you more *susceptible* to illness.
   a. sensitive b. resistant

6. Virus *infections* cannot be cured with antibiotics.
   a. diseases b. organisms

7. The accident victim did not know what happened because he was *in a coma*.
   a. unconscious b. awake

8. Calcium is *obtained* from the electrolysis of calcium chloride.
   a. destroyed b. gotten

9. Coffee *stimulates* the nerve centers.
   a. quiets b. excites

10. The view from the mountain produced a *sensation* of dizziness.
    a. fear b. feeling

11. He retired from his job when he developed a *chronic* illness.
    a. long lasting b. brief

12. The needle was sterilized before the *injection*.
    a. insertion b. removal

13. The *initial* research was inconclusive, so a second experiment was planned.
    a. last b. first

14. The mountain climbers suffered from *exhaustion* when they reached the top.
    a. fatigue b. hunger

15. AIDS is a *fatal* illness for everyone who contracts it.
    a. deadly b. mild

16. To lose weight, he took pills to *suppress* his appetite.
    a. release b. restrain

17. A straight stick submerged in water will appear *distorted*.
    a. out of shape b. colored

18. Human beings have little *tolerance for* extremes in temperature.
    a. fear of b. resistance to

19. The experiment had *consequences* that were not anticipated.
    a. causes b. results

Skimming

Skimming for main ideas is a reading skill that is useful in a number of ways:

1. Always skim a textbook chapter before reading it closely. If you follow this procedure, you will read faster and with greater interest and comprehension.
2. When you need to write a research paper, skim the references you find in the library to see which contain the material you need.
3. Skim any passage that you find difficult. Once you have a general idea of the content and organization, you will be able to read it thoroughly with better understanding.

See p. 27 to review skimming techniques.

Skim the following passage in three minutes and then answer these questions:

1. Which of the following is the main idea?
   a. Drugs are always potentially harmful.
   b. Drugs are not harmful.
   c. Drugs are occasionally harmful but usually beneficial.
2. Which of the following drugs are discussed in the passage:
   cocaine, amphetamines, PCP, inhalants, narcotics, caffeine, marijuana, barbiturates, and hashish?

Reading

The Danger of Drugs

Drugs are substances that alter the body chemistry. The pleasing effects of any drug should be weighed carefully against its serious dangers.

Marijuana is a drug that has been much discussed and debated. It relaxes the mind and body and produces a pleasant, happy feeling in many users. At the same time, it can alter functions that may affect the memory, coordination, motivation, and attention span of the user. Although its effects may be less harmful than alcohol, it should not be assumed that it, or any drug, is harmless.

Narcotics (codeine, heroin, opium and morphine) are considered "hard drugs" and are addictive, or habit forming. They act as depressants on the nervous system, relieving pain and decreasing alertness and vigor. Heroin makes the user lethargic and highly susceptible to infection, coma, and even death from overdose. Because heroin is addictive, it often leads the user to crime to pay for the high cost of obtaining the drug. Another narcotic, morphine, is used by hospitals as a pain reliever. Occasionally, patients receiving morphine become addicted.

Cocaine (or "coke") is a drug that stimulates the nervous system, producing a feeling of well-being and strong sensations. Sniffing cocaine powder over a long period can cause paranoia, hyperactivity, and chronic insomnia. "Crack," a form of cocaine that is smoked, is especially dangerous because the user can become intensely addicted in a very short period of time. Like heroin, it frequently leads the user to crime.

Amphetamines (called "speed" or "uppers") include Benzedrine, Dexedrine, and Methedrine. These drugs increase the blood pressure and stimulate the nervous system to give the user great bursts of energy. In small amounts, they are used by students and drivers to stay awake, by athletes to improve their physical performance, and by dieters to decrease their appetite. However, injections of amphetamines bring on initial feelings of energy and well-being that are followed by low periods of depression, exhaustion, irritability, and aggressiveness. An overdose of amphetamines can be fatal.

Barbiturates, or "downers" (sleeping pills), act on areas of the brain to reduce anxiety and cause sleepiness. The effects include loss of muscle coordination, slurred speech, and mental confusion. The use of barbiturates and alcohol together can suppress the breathing centers and be fatal.

Psychedelics, or hallucinogens (including LSD and mescaline), are drugs that produce hallucinations and other mental disorders. Their effects are somewhat unpredictable. Psychedelics can cause changes in mood, thinking, and behavior and distortions of time and space. Effects include dizziness, nausea, anxiety, and tremors.

With the exception of marijuana, research indicates that most of the above drugs are addictive. Users build up a tolerance for the drug, requiring increasing doses to achieve the same effects. Sometimes an addict's tolerance may be dangerously high, and a fatal amount is taken accidentally. Anyone considering using any drug should be aware of the potentially serious consequences.

Understanding the Reading. Indicate whether each of the following statements is true (*T*) or false (*F*) according to the previous passage.

__F__ 1. Only certain drugs alter the body's chemistry.

_____ 2. There is no correlation between the use of marijuana and a decrease in motivation.

_____ 3. Marijuana is less dangerous than alcohol and therefore is probably harmless.

_____ 4. Morphine cannot become addictive when used by hospitals as a pain reliever.

_____ 5. A significant danger of heroin is that it is so addictive.

_____ 6. Cocaine has no long-term harmful effects.

_____ 7. Cocaine is one drug that is not addictive.

_____ 8. Some students use amphetamines because they provide temporary bursts of energy.

_____ 9. Even an overdose of amphetamines will probably not be fatal.

_____ 10. Barbiturates are particularly dangerous when taken with alcohol.

_______ 11. Scientists can predict with reasonable accuracy the effects of LSD on the user.

_______ 12. A user who builds up a tolerance for a drug is in danger of a fatal overdose.

LISTENING SKILLS

Vocabulary in Context. Circle the letter of the answer that best matches the meaning of the italicized word as it is used in each of these sentences.

1. Cocaine has *physiological* as well as psychological effects.
   (a.) physical b. mental
2. Exercise is *beneficial* for a healthy individual.
   a. dangerous b. good
3. The message was *transmitted* by electronic mail.
   a. received b. sent
4. The accident occurred because the driver was *intoxicated.*
   a. arrested b. drunk
5. Old age brings the gradual *degeneration* of the body.
   a. strengthening b. weakening
6. High doses of radiation can affect reproduction and cause a person to be *sterile.*
   a. strong b. unable to have children
7. Sugar has a *detrimental* effect on your teeth.
   a. harmless b. harmful
8. Dust *accumulated* on the engine, impairing its function.
   a. evaporated b. gathered
9. If a tail is cut off, a lizard has the *capacity* to grow a new one; a cat does not.
   a. need b. ability
10. The condition of the building *deteriorated* because the tenants did not take proper care of it.
    a. worsened b. improved

Note-Taking

After writing down main ideas, try to write down any evidence that supports these ideas. Facts, statistics, results of experiments, and explanations are worthwhile jotting down if you have time. The evidence reinforces the main concepts and helps you to recall them later.

Take notes as you listen to the lecture "The Physiological Effects of Alcohol." Try to write down evidence in addition to the main points. Then use your notes to complete the next exercise.

Understanding the Lecture. Use your notes to determine whether each of the following statements is true (*T*) or false (*F*) according to the information in the lecture.

F 1. Since small amounts of alcohol make people feel good, large amounts make them feel better.

_____ 2. Even small quantities of alcohol depress the heart rate.

_____ 3. Small quantities of alcohol may relieve tension.

_____ 4. The unclear speech and blurred vision of intoxicated people is evidence that alcohol affects the nervous system.

_____ 5. Alcoholism can inflame the muscles and cause enlargement of the heart.

_____ 6. Chronic alcoholism can cause sterility.

_____ 7. Although harmful in other ways, alcohol has a beneficial effect on the liver.

_____ 8. There is no evidence that alcohol affects the brain.

_____ 9. It is all right for pregnant women to consume alcohol after the early months of pregnancy.

_____ 10. Some people become addicted more easily than others.

_____ 11. Drinking strong black coffee will help a person overcome the effects of alcohol.

_____ 12. Short-term beneficial effects of alcohol are usually outweighed by long-term negative effects.

DISCUSSION POINTS

Be prepared to give your opinion on one of these topics, offering evidence for why you think the way you do.

1. Should advertising for cigarettes be banned?
2. Should advertising for alcohol be banned?
3. Should students be expelled from high school for using drugs on campus?
4. Should people convicted of drunken driving have their licenses taken away?
5. Should marijuana be legalized?
6. Should the minimum age for drinking be changed?
7. Should smoking be banned from public places?

WRITING SKILLS

Giving Evidence

Scientific writing requires that you provide evidence to support your statements. The more evidence you have and the better it is, the stronger your statement or argument will be. In Chapter 6 we discussed the use of examples, but there are other forms of evidence, including facts, statistics, observations, test results, survey results, and expert opinion. Discuss which of these forms of evidence are used in each of the examples below. (An example may include more than one form of evidence.)

1. The process of evolution may be over for human beings. For thousands of years, human beings have been changing their environment instead of being changed by it.
2. A danger exists that the ozone in the upper atmosphere may be destroyed by man-made chemicals, allowing harmful ultraviolet light to reach the earth. This was first discovered in 1983 by a team of British scientists who demonstrated that concentrations of ozone were decreasing in the stratosphere over Antarctica.
3. The death rate from traffic accidents on U.S. roads does not increase on holiday weekends. Although the number of fatalities increases by about one percent, there are about three percent more drivers on the roads.
4. Drinking appears to increase the incidence of hypertension, according to tests performed on adult men by researchers at Stanford University.
5. By the middle of the 21st century, a significant part of the world's electricity will be supplied by controlled thermonuclear fusion, according to reports issued by the U.S. Department of Energy.
6. Researchers at a midwestern college of medicine interviewed thirty creative writers and found an association between creativity and mental disorders such as depression and manic depression.

Writing with Evidence

Write a paragraph on one of the Discussion Points. First state your opinion as the topic sentence and then provide evidence to establish the credibility of your point. Conclude by summarizing your ideas, stating their significance, or recommending actions the reader might take.

chapter 8

Experimenting

Electricity and Magnetism

INTRODUCTION

The ancient Greek philosophers obtained their knowledge about the universe from reasoning and logic. But Galileo's experiments proved that Aristotle's reasoning was not always valid. Since then, no scientific concept is accepted unless there is evidence to support it.

When testing a hypothesis, every effort is made to eliminate subjective or biased ideas. If experiments do not support a hypothesis, the hypothesis must be rejected or modified. The twentieth-century writer-scientist Isaac Asimov wrote: "Even though billions of observers tend to bear out a generalization, a single observation that contradicts or is inconsistent with it must force its modification."*

Sometimes an experiment proves something other than what the researcher intended. Many great discoveries were accidents of an experiment. In 1929, for example, the Scottish researcher Sir Alexander Fleming noticed that some bacteria had been destroyed by a mold. He had accidentally discovered penicillin. In 1895, the German scientist Wilhelm Roentgen noticed that cathode rays penetrated black paper. Thus, x-rays were discovered. While experimenting, the scientist needs to keep a sharp eye and an open mind.

*Isaac Asimov, *Asimov's Guide to Science* (New York: Basic Books, 1972), p. 13.

Short Reading

Read the following passage to find directions for performing an experiment.

Lightning Strikes

You know that lightning is actually electricity. But how does lightning occur? The ancient Greeks noticed that when they rubbed a piece of amber* with wool or fur, the amber would attract or pick up small pieces of leaves or dust. This was called the amber effect. The English word *electricity* comes from the Greek word *electron*, which means amber. To demonstrate this concept, perform the following experiment:

1. Arrange tiny pieces of paper on a table.
2. Rub a plastic comb with some woolen fabric.
3. Hold the comb over the pieces of paper and observe what happens. The paper should be attracted to the comb. (*Note*: The comb must be rubbed again to sustain its magnetic capacity.)

In the eighteenth century, scientists discovered that there are two types of electric charge. The American Benjamin Franklin named these charges positive and negative. It was noted that like charges repel each other and unlike charges attract each other.

In the experiment above, the magnetic effect occurs because rubbing the comb causes some electrons from the cloth to run on to the comb. The cloth then has fewer electrons (which are negative) and thus becomes positively charged. The comb therefore has additional electrons, giving it a negative charge. The comb attracts the paper because opposite charges attract. Similarly, you have probably experienced an electric shock when you removed synthetic clothing from a clothes dryer, combed your hair, or touched a metal doorknob after walking across a thick rug.

A spectacular example of this phenomenon occurs during a storm. Inside a cloud, currents of air rub against the raindrops. As the electrons are rubbed off, one cloud becomes positively charged and another negatively charged. The opposite charges attract each other, and an enormous spark of electricity jumps from one cloud to another or from a cloud to the ground. Thus, lightning is produced.

USING ENGLISH TO GIVE DIRECTIONS

An experiment is a kind of process. We analyze a substance, such as air, by separating and identifying its components. We analyze a process by breaking it down into steps or procedures and arranging them in chronological order (the order in which things happen).

*Amber is a hard, yellowish-brown substance found in certain soils.

Giving Directions to Perform a Process

It is usually preferable to write directions as a list of steps rather than a paragraph. The imperative form of the verb is used. The subject (you) is implied, never stated:

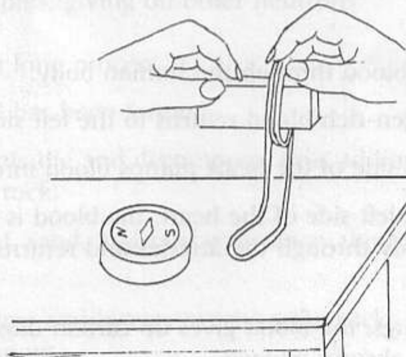
1. ***Arrange* tiny pieces of paper on a table.**
2. ***Rub* a plastic comb with some woolen fabric.**
3. ***Hold* the comb over the pieces of paper and *observe* what happens. The paper should be attracted to the comb.**

Notice that a verb may give directions for both mental and physical activities. Notice also the parallel form of the above list. Every clause begins with an imperative verb. One sentence (*The paper should be . . .*) does not have an imperative verb because it does not give a direction.

Imperative Verbs

Imperative verbs:

1. give a command or direction;
2. appear at the beginning of a clause;
3. have a subject that is implied, *not* stated (you); and
4. are formed from the present tense of the verb.



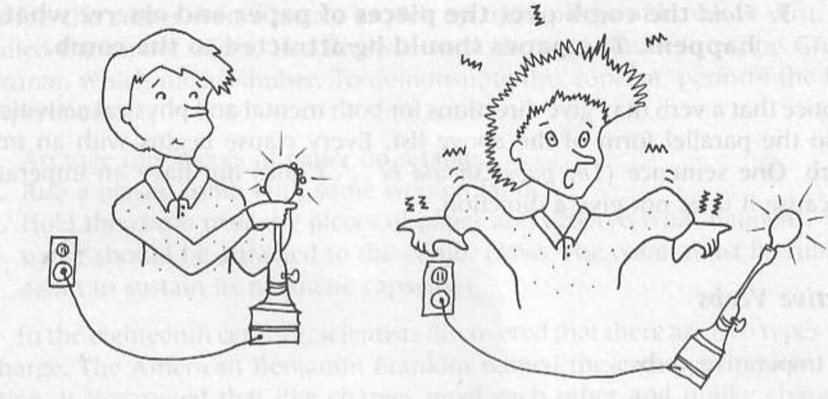
Recognizing Imperative Verbs. Below are the directions for performing an experiment showing how magnetism produces electricity. Notice that each item is a separate step in the process. Underline all the imperative verbs.

1. Make several loops in a coil of wire.

2. Tie the ends of the wire together.

3. Insert a magnet through the coil.

4. Move the magnet back and forth through the coil.
5. Place a compass near the wire but away from the magnet.
6. Check the compass to see if the needle is moving. (A moving needle indicates that electric current is flowing through the wire and that magnetism can produce electricity.)



Remove the bulb . . . after disconnecting the electricity.

Arranging Items Chronologically. When explaining a process, it is essential to describe steps in the order in which they happen, that is chronologically. Number each group of steps below in chronological order. The first step has been indicated in each list.

1. The heart pumps blood through the human body.

__3__ The oxygen-rich blood returns to the left side of the heart.

__1__ The right side of the heart pumps blood into the lungs.

__4__ From the left side of the heart, the blood is pumped out to the rest of the body through the arteries and returns to the heart through the veins.

__2__ In the lungs, the blood gives up carbon dioxide (which we breathe out) and absorbs oxygen.

2. It is easy to print a simple message on this computer.

_____ Turn off the computer.

_____ Type the first line.

__1__ Turn on the computer.

_____ Press the RETURN key after typing each line.

_____ Press the PRINT key before typing each line.

3. The age of a rock is calculated by measuring the amount of its uranium that has been converted to lead.

   ___1___ Uranium, a radioactive element, changes into thorium.

   _______ Lead is not radioactive and remains stable.

   _______ Radium converts to lead.

   _______ Thorium, also radioactive, turns to radium.

4. Mitosis is the process of cell division.

   ___1___ When a cell grows to a certain size, it begins to divide.

   _______ A cell wall forms through the center of the cell.

   _______ Two separate "daughter cells" have thus been completely formed.

   _______ The cell's chromosomes begin to separate into two groups and pull toward opposite ends of the cell.

5. The power of a nuclear explosion is produced by the splitting of the atom.

   _______ This results in a chain reaction of splitting atoms, releasing an enormous amount of energy.

   _______ The other neutrons then split other uranium atoms.

   ___1___ When the nucleus of a uranium atom is hit by a neutron, the nucleus splits, giving off other neutrons.

6. Soil formation is a long process.

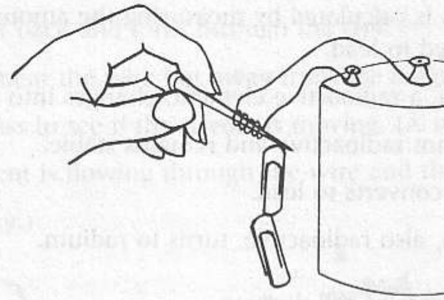
   _______ Good soil has been formed.

   _______ Then plants die and decompose, thus adding humus to the tiny pieces of rock.

   ___1___ First wind, sand, and rain wear away the rocks, producing tiny particles.

   _______ Earthworms and insects overturn the rocks and humus, mixing everything up.

Using Imperative Verbs. Using the following illustration as a guide, write directions for making an electromagnet with a battery, insulated wire, and a nail. Begin each step with an imperative verb and make sure all steps are in chronological order.



Verb Forms: Infinitives and Gerunds

In an English sentence, when one verb follows another, the second verb can take one of three forms:

1. an infinitive (*to advance, to detect*),
2. an infinitive without *to* (*advance, detect*), or
3. a gerund (*advancing, detecting*).

Students of English as a second language frequently find this confusing. How do you determine which form of the verb to use? The answer is that the first verb determines the form of the second. For example, the verb *begin* may be followed by an infinitive or a gerund. The verb *plan* must be followed by an infinitive. The modal *must* may only be followed by an infinitive without *to*. The verb *observe* may be followed by a gerund or an infinitive without *to*. Here are some examples:

Einstein *began to study* the photoelectric effect.
Einstein *began studying* the photoelectric effect.
Researchers *planned to repeat* the experiment.
Researchers *must repeat* the experiment.
Astronomers *observed* the supernova *exploding*.
Astronomers *observed* the supernova *explode*.

Below is a list of some verbs that are useful in scientific writing:

1. Verbs followed by infinitives:

learn	manage	expect	appear
prepare	arrange	fail	encourage
plan	agree	neglect	inspire
decide	offer	refuse	tend
determine	hope	seem	help

2. Verbs followed by infinitives without *to*:

Modals		*Verbs of the Senses**		*Other Verbs*
can	will	see	watch	let
could	would	hear	observe	make
may	shall	feel	notice	help
might	should			
must				

3. Verbs followed by gerunds:

stop	deny	consider
finish	delay	involve
admit	postpone	risk
avoid	anticipate	keep
resist	suggest	prevent

4. Verbs followed by either infinitives with *to* or gerunds:

begin	permit	choose
start	allow	prefer
continue	remember	intend
try	forget	like
attempt	regret	propose

A good way to master these verb forms is to practice using them in short phrases until their correct use becomes a habit:

I can go, I could go, I may go, I might go, I will go
I learned to drive, I prepared to drive, I planned to drive
We stopped studying, we finished studying, we avoided studying

Choosing Verb Forms. Circle the letter of the correct form of the verb in each of these sentences.

1. The monitoring device could ________ alpha particles in the atmosphere.
   (a.) detect b. to detect
2. Metals are called reducing agents because they tend ________ electrons.
   a. losing b. to lose
3. We expected ________ the thunder after we saw the lightning.
   a. hearing b. to hear

*These verbs can also be followed by a gerund. For example, *We saw the baby birds hatching in their nest. The inhabitants could feel the earth trembling.*

4. The wound stopped ________ when pressure was applied.
   a. bleeding b. to bleed
5. Some scientists believe that life might ________ on Saturn's moon Titan.
   a. exist b. to exist
6. Galileo's work inspired Newton ________ motion.
   a. to study b. studying
7. We felt the house ________ when the train went by.
   a. vibrating b. to vibrate
8. Many animals would ________ extinct if they were not bred in captivity.
   a. become b. becoming
9. The cafeteria only allows students ________ in certain areas.
   a. smoke b. to smoke
10. In the 1920s, evidence began ________ that all galaxies were rushing away from ours.
   a. to indicate b. indicate

READING SKILLS

Vocabulary Building

Like prefixes and suffixes, word roots can help you acquire and remember new words. The root of a word (sometimes called the *stem*) is the base from which it is formed. The root is the part most likely to give you a clue to the meaning of the word. An English word may be built from one or more roots, with or without prefixes, suffixes, or both. Here are some examples:

***synchronize*—to happen at the same time**
- ***syn-* (prefix meaning *together* or *with*)**
- ***-chrono-* (root meaning *time*)**
- ***-ize* (suffix indicating verb)**

***dissonance*—unpleasant sound**
- ***dis-* (prefix meaning *not*)**
- ***-son-* (root meaning *sound*)**
- ***-ance* (suffix indicating noun)**

***photoelectric*—pertaining to the emission of electrons when a substance is exposed to light**
- ***photo-* (root meaning *light*)**
- ***-electro-* (root meaning *electricity*)**
- ***-ic* (suffix indicating adjective)**

Note that in all the above examples, the root is the part of the word that gives the strongest clue to its meaning. The prefix modifies or adds to the meaning of the root. The suffix indicates the part of speech (noun, verb, adjective, or adverb).

The word roots taught in this book are commonly found in scientific words. After a while, these and other roots will become familiar as you see them again and again.

***Word Roots:* bio-, aero-, thermo-, hydro-.** Study the following list of word roots and then match the terms at the left below with their meanings at the right. You will not use all the meanings listed.

***bio-*: life;**
***biology* = the study of living things**

***aero-*: air;**
***aeronautics* = the science of operating aircraft**

***thermo-*: heat;**
***thermometer* = a device for measuring heat**

***hydro-*: water;**
***hydroelectricity* = electricity produced by water power**

e 1. biochemistry
_______ 2. biosynthesis
_______ 3. aerodynamics
_______ 4. aerobe
_______ 5. thermostat
_______ 6. thermodynamics
_______ 7. hydrous
_______ 8. hydraulic
_______ 9. dehydration

a. instrument for measuring specific gravity
b. device for regulating indoor temperature
c. study of the movement of air and other gases
d. use of water pressure for mechanical means
e. study of the composition of plants and animals
f. containing water
g. process of losing water
h. combination of elements by a living thing
i. organism that lives only in the presence of oxygen (air)
j. study of the conversion of heat into mechanical energy and the reverse

Vocabulary in Context. Circle the letter of the answer that best matches the meaning of the italicized word as it is used in each of these sentences.

1. Oil and water *repel* each other.
   a. attract (b.) resist
2. The possibility of life existing elsewhere in the universe is *intriguing* to many scientists.
   a. ridiculous b. interesting
3. Marie and Pierre Curie were able to *isolate* a new radioactive element, radium.
   a. separate b. create
4. The bridge was *suspended* from cables supported by towers at either end.
   a. hung b. separated
5. The hands on the dial *pivoted* as the gas pressure was raised and lowered.
   a. rotated b. reversed
6. The blueprint for the machinery was *accurate* except for one error.
   a. correct b. incorrect
7. To make sure the names were chosen by chance, the computer was programmed to list them *at random*.
   a. without order b. in order
8. During the eclipse, the earth, sun, and moon were *aligned*.
   a. in a line b. out of line
9. The experiments were conducted *simultaneously* in London and Rome.
   a. in the same place b. at the same time

Scanning

Scan the following passage in three minutes and put square brackets around the answers to these questions. (First identify the key words.)

1. Who was William Gilbert?
2. Where is the magnetic North Pole?
3. What did Michael Faraday and Joseph Henry both discover?

Reading

The Magic of a Magnet

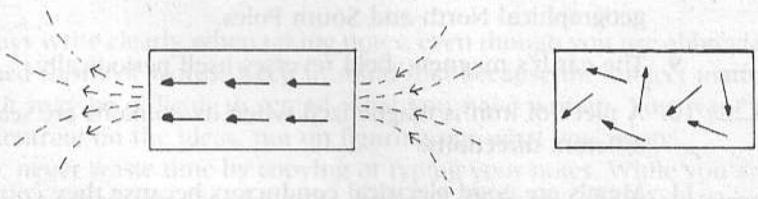
What is the magic that enables a magnet to pick up an iron nail but not a wooden pencil, a rubber eraser, or a copper penny? Magnetism, named for the ancient Greek town of Magnesia, is a force of nature that manifests itself differently in different materials. Although every substance is magnetic to some degree, magnetic effects are much more powerful with iron and steel than with materials such as wood, rubber, copper and glass.

If you have ever played with two magnets, you know the powerful force with which certain ends are drawn toward each other and other ends push away from each other across space. The magnets' two north poles repel each other and their two south poles attract each other.

Physicists have always been intrigued by the fact that when a magnet is cut in half, two new magnets are formed, each with a north and south pole. If we were to cut these two magnets, we would have four magnets, each with a north and south pole. The north pole cannot be isolated from the south pole. Magnetic poles never exist alone.

The ability of magnetic iron ores, or lodestones, to attract iron and other substances was known to the ancient Greeks. Later, around the year 1100, the Chinese discovered that if a splinter of lodestone were suspended from a thread, it would pivot and point north and south, thus making a very accurate compass. This phenomenon was explained in 1600 by William Gilbert, Queen Elizabeth's doctor, who speculated that the earth itself was a gigantic magnet.

The earth's magnetism is one of the great mysteries of science which no one has been able to explain. Although the earth has an iron core, that core cannot be a magnet because at great heats (over 1000° C at the center of the earth) iron loses its magnetism. Another mystery is the fact that the magnetic poles are actually located over a thousand miles from the North and South Poles and they are not even at exactly opposite sides of the earth. In addition, by studying the age of rocks, scientists have discovered that from time to time in the history of the earth, the earth's magnetic field actually reverses itself as the magnetic South Pole becomes the magnetic North Pole and vice versa!



Magnetized iron **Unmagnetized iron**

When viewed under an electron microscope, a piece of iron can be seen to be made up of many tiny magnetic areas called domains. When these domains are orderly arranged, the iron is magnetized. When these domains are randomly arranged, the iron will not act as a magnet. This explains why a magnet will pick up unmagnetized pieces of metal such as a steel paper clip. The force of the magnet causes all the tiny magnetic domains of the paper clip to align themselves. Then the north pole of the paper clip is attracted to the south pole of the magnet, and the south pole of the paper clip is attracted to the north pole of the magnet.

In 1832, the connection between magnetism and electricity was simultaneously discovered by the Englishman Michael Faraday and the American Joseph Henry.

They found that when a magnet is passed through a coil of wire, it produces an electric current in the wire. This occurs because the wire contains unattached electrons. A magnetic field moving near the wire pulls these free electrons along the wire, creating an electric current.

Not only does a moving magnetic field induce electricity, but the opposite is also true. Electric currents produce magnetism. When a current of electricity is passed through a conductor, a magnetic field forms around it. Thus a magnetic field may be induced by an electric current. Scientists believe that all magnetic fields are produced by electric currents. This is the true magic of a magnet.

Understanding the Reading. Indicate whether each of these sentences is true (*T*) or false (*F*) according to the previous passage.

__T__ 1. All substances are somewhat magnetic.

_____ 2. Magnetic poles that are alike attract each other.

_____ 3. A magnet can exert its force across an open space.

_____ 4. A north pole of a magnet cannot exist separately from a south pole.

_____ 5. Compasses were used by the ancient Greeks.

_____ 6. William Gilbert suggested that a compass needle points north and south because the earth is a magnet.

_____ 7. We know that the earth is a magnet because it has an iron core.

_____ 8. The magnetic poles of the earth are located precisely at the geographical North and South Poles.

_____ 9. The earth's magnetic field reverses itself periodically.

_____ 10. A piece of iron is magnetized when its domains are scattered in different directions.

_____ 11. Metals are good electrical conductors because they contain many loose electrons.

_____ 12. Magnets can produce electricity, but electricity cannot produce magnetism.

LISTENING SKILLS

Vocabulary in Context. Circle the letter of the answer that best matches the meaning of the italicized word as it is used in each of these sentences.

1. The astronomy class studied the sun, the moon, and other *celestial* objects.
   a. heavenly b. imaginary
2. In 1986, a *massive* earthquake in Mexico City killed many people.
   a. huge b. moderate
3. Benjamin Franklin noticed the *repulsion* of like electrical charges.
   a. dislike b. attraction
4. Although a lit cigarette started the forest fire, the *underlying* cause was the lack of rainfall.
   a. immediate b. basic
5. The policeman used a clean towel to *bind* the wound.
   a. tie b. open
6. Californians are *aware* of the threat of earthquakes.
   a. conscious b. ignorant
7. An atom has no charge because positive protons *cancel* negative electrons.
   a. neutralize b. dominate

Note-Taking

Always write clearly when taking notes, even though you use abbreviations and shortened forms of words. Keep in mind that because the subject matter is unfamiliar, it may be difficult to reread what you have written. You want to be able to concentrate on the ideas, not on figuring out what you wrote.

Also, never waste time by copying or typing your notes. While you are copying or typing, you are *not* absorbing the material. Make the effort to write clearly the first time.

Take notes as you listen to the lecture "The Four Forces" and then use your notes to complete the next exercise.

Understanding the Lecture. Based on the information in the lecture, indicate whether the force described in each of these phrases is gravitational (*G*), electromagnetic (*E*), strong nuclear (*SN*), or weak nuclear (*WN*).

___E___ 1. The force that causes friction.

_______ 2. The weakest force.

_______ 3. The most important force.

_______ 4. The force that holds atoms and molecules together.

_______ 5. The force that holds protons together.

_______ 6. The force that sticks tape to a piece of paper.

_______ 7. The force that keeps planets in orbit.

_______ 8. The force that appears in radioactivity.

_______ 9. The force that attracts but does not repel.

_______ 10. The two forces that function only inside an atom.

_______ 11. The force that is strongly felt because planets are so large.

_______ 12. The contact force.

_______ 13. The basic force of chemistry.

DISCUSSION POINTS

Give verbal directions to fellow students to complete some procedure. You might want to choose from the following suggestions:

1. Play a game from another country.
2. Cook a dish from another country.
3. Perform an experiment not discussed in this class.
4. Make something by hand.
5. Perform an activity such as changing the oil in a car, repairing a radio, or developing film.

Plan your talk carefully so that all necessary steps are included. A major metropolitan newspaper once printed a recipe that included a step that said to remove the chicken from the pot. Unfortunately, the step that said to *put* the chicken in the pot had accidentally been omitted. One lady wrote that she had followed the recipe carefully but was very confused when she looked in her pot for the chicken and could not find it! As you prepare your talk:

1. List all the steps in the procedure.
2. Make sure that each step is separate and distinct and that nothing has been omitted.
3. Arrange the steps in chronological order.

Your topic sentence will be a statement of the purpose of your talk. A good way to conclude is to explain how this information might be used.

WRITING SKILLS

Directions

In a science fiction story by the American writer Isaac Asimov, two astronauts on a mission far from earth are unable to operate their space station because they cannot understand the written instructions for assembling the equipment. When they notify earth of their predicament, they are told they will receive a robot that can follow the instructions and assemble the equipment. At last the box arrives. They open it excitedly only to find the robot in 500 separate pieces with one page of confusing instructions on how to assemble it!

The moral of this story is, of course, to make sure your written directions are clear. The following are guidelines for writing directions:

1. List all the steps in the process.
2. Begin each step with an imperative verb.
3. Arrange the steps in strict chronological order.
4. Keep the sentences fairly short. (Do not put more than one step together.)
5. Include all necessary details, such as specific quantities, measurements, and dates.
6. Check to see that you have not omitted anything or included any unnecessary steps.

Writing Directions

Following the guidelines listed above, write instructions for following a procedure to do or make something. Choose one of the Discussion Points or a topic of your own.

chapter 9

Calculating

Liquids and Gases

INTRODUCTION

To a large extent, mathematics is the language of science. The accuracy of predictions depends on the accuracy of the measurements and computations used in experimentation. We have come a long way since ancient times, when mathematics was regarded by some, like Plato, as mysterious or supernatural; when numbers like seven or thirteen were thought to have magical powers for good or bad luck; and when members of certain brotherhoods were put to death for revealing mathematical "secrets" that are common knowledge today.