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CHAPTER

2 DESCRIBING TIME

2-1 Chronological Time

No description of an object or event is complete without placing the object or event in the context of time. For example, if you heard a description of a large mammal with a long trunk and tusks, you would immediately assume that the mammal described was an elephant. However, if you found out that the mammal lived about 10,000 years ago, you might change your mind about the identity of the animal. The animal described was in fact a mammoth, a close relative of today's elephants. Do you see how much difference time can make to an accurate description?

What are some of the ways you use time to organize your life or make sense of the world? Think about it for a moment. Think how different life would be if there were no clocks or watches. This was the case for most of human history. Try to describe what you did yesterday in detail without using any references to the time of day or night. You will find it challenging. Before humans had the concept of the 24-hour day, or the calendar year, events were recalled by relating them to other events that occurred at the same time. For example, Egyptian accounts of events often relate the time of events to the time of the annual flooding of the Nile. Every Egyptian knew when the Nile River flooded in a given year. Therefore, if you told someone that your little brother was born during the last flood, he or she would know exactly when the baby was born.

This method of relative time description only works if the person you are describing the event to knows about your reference. If an Egyptian traveled to China and told a Chinese person that his little brother was born during the last flood, the Chinese person would have no idea when the event occurred.

Now we use a system of years, months, days, hours, minutes, and seconds as a common reference for periods of time. Everyone in the world understands the same reference. Keep in mind that other calendars and methods of time keeping still exist, but the idea of a 24-hour day and a 364- or 365-day year is accepted worldwide.

Time is used in scientific writing in two different ways: *chronological time* and *process time* (a sequence describing a process). **Chronological time** is used for historical events and developments and for things that happen over a period of time. It can be a short period such as hours, days, or weeks. Or it can be a long period such as years, decades, centuries, or billions of years. Read the following passage, which discusses the age of the planet Earth. It has several **specific time markers.** A specific time marker is a word or phrase that contains a date or indicates the passage of time. **Table 2-1** lists some of the possible specific time markers.

Earth's Age

The estimated age of Earth, more than 4 billion years, is about 700,000 times as long as the period of recorded history. It is about 50 million times as long as the average human life span. How can we determine what happened so long ago? Scientists have drilled deep into Earth and have examined its many layers to establish a fairly complete picture of its geologic history. Early estimates of Earth's age were made from studying layers of sediment in Earth's crust. The age of Earth could not be estimated accurately, however, until the middle of the twentieth century, when modern methods of establishing the age of materials were developed.

(from Modern Biology)

The above passage contains four specific time markers. Can you locate them? The first three give estimates of the age of Earth: *4 billion years, 700,000 times as long as the period of recorded history,* and *50 million times as long as the average human life span.* The fourth time marker in the passage refers to the time at which the age of Earth could be accurately estimated, *the middle of the twentieth century.* Exercise 1 gives you more practice identifying specific time markers.

Table 2-1 Specific Time Markers

1 hour	60 minutes
1 day	24 hours
1 week	7 days
1 year	365 days 12 months
1 decade	10 years
1 century	100 years
1 millennium	1000 years
the twentieth century	1901–2000
half past noon	12:30 P.M.
new year's eve	December 31

Exercise 1 **Time Markers**

a. Read the following passage and pick out the specific time markers that appear. Write the word or phrase of the time marker on the lines provided. The first marker that appears in the passage is written for you on line (i) as an example.

Life Begins

The earliest traces of life are found as tiny fossils in 3.5-billion-year-old rocks from the ancient seas. Earth's first cells were bacteria. Unlike the interior of today's plant and animal cells, the insides of these early forms were like a warehouse—an open space within which all of the contents of a cell were free to move about. For over a billion years, bacteria were the only living things on Earth.

Then, about 1.5 billion years ago, a new kind of organism called the protist, evolved. Most protists are single-celled organisms. The next stage is the appearance of multicellular organisms. The first known fossils of multicellular organisms were found in 630-million-year-old rocks from southern Australia.

All the major groups of organisms that survive today, except plants, originated sometime during the first hundred million years of this period, which is called the Cambrian period. The Cambrian period lasted from just less than 600 million years ago to about 500 million years ago. Life was more diverse in the Cambrian seas than it has ever been since.

In the time span following the Cambrian, a period known as the Ordovician, the seas continued to teem with all forms of living things. The end of the Ordovician period is marked by a drastic change in the fossil record. A large portion of all life-forms suddenly disappeared from Earth, about 440 million years ago. This major mass extinction was the first of five that have occurred during the history of life on Earth.

Another mass extinction of similar magnitude happened abruptly about 360 million years ago. Then, about 100 million years later, the third and greatest of all mass extinctions literally devastated our planet. It happened at the end of what is called the Permian period, about 250 million years ago. At that time, about 96 percent of all animals became extinct. Approximately 35 million years later, a fourth, less devastating mass extinction occurred. Although the specific causes for these events are not clear, evidence suggests that massive geological or climatic changes had come over Earth.

(from Biology: Principles and Explorations)

i. *3.5-billion-year-old*

ii. ______________________________

iii. ______________________________

iv. ______________________________

v. ______________________________

vi. ______________________________

vii. ______________________________

viii. ______________________________

ix. ______________________________

x. ______________________________

xi. ______________________________

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b. The timeline below indicates periods and events involved in the evolution of organisms on Earth. Using the passage, add approximate dates to the timeline.

Precambrian period	Earliest traces of life found as tiny fossils	
	Protists evolve	
Cambrian period	Life on Earth reaches peak of diversity	
Ordovician period		
Devonian period	First mass extinction	
Carboniferous period	Second mass extinction	
Permian period	Third mass extinction	
Jurassic period	Fourth mass extinction	

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CHAPTER

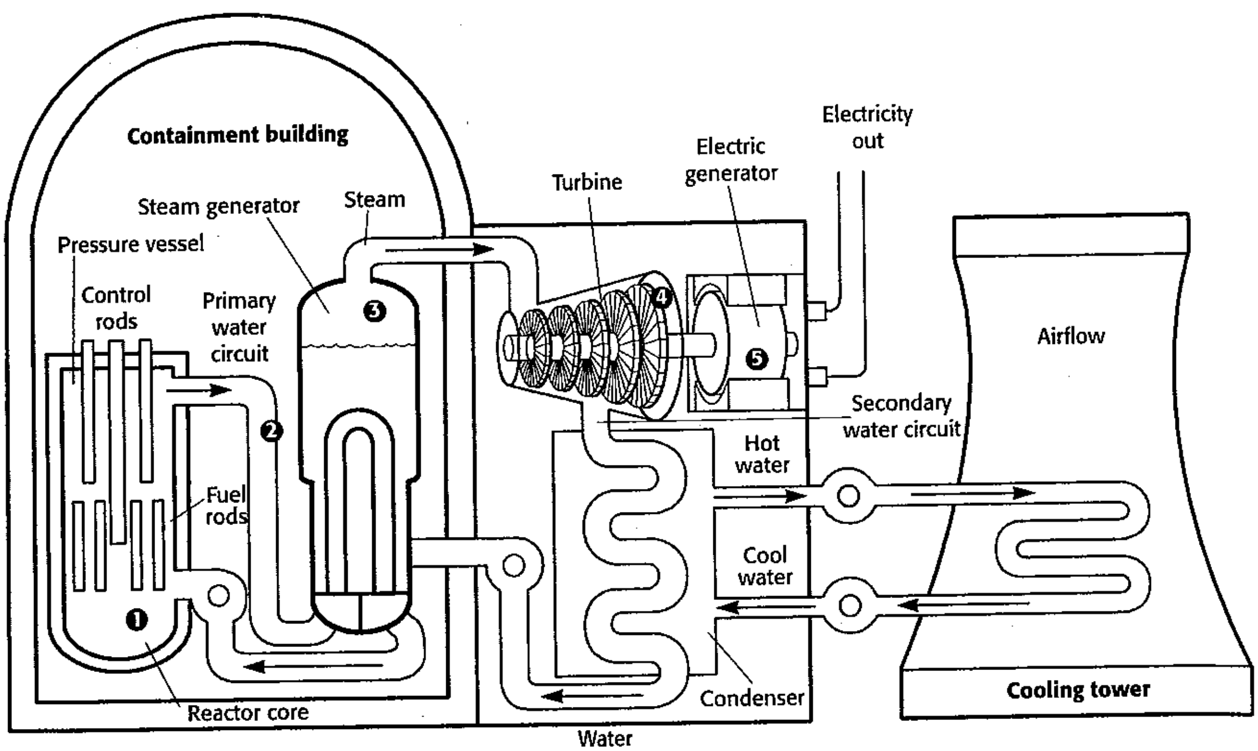
2 DESCRIBING TIME

2-2 Process Time

Process time is used to indicate a **sequence.** A sequence is a series of steps leading to some end, result, or conclusion. Read the two sample passages on the following page that use sequences to describe processes. Notice the sequence of events depicted in each passage. The illustrations that accompany the passages will help you visualize the processes described in the text. Many of your science texts will include words, as well as images, to help you learn about scientific processes. You must be able to use both to gain a complete understanding of the topics.

The two passages illustrate two different ways of writing process time. The first passage, "How a Nuclear Power Plant Works," is written as a numerical sequence. Each sentence is numbered, and the events occur in the order of the numbered sequences. The numbers also provide an easy reference to the picture that accompanies the text. Try to follow the steps written in the passage by comparing them to the numbered parts of the image.

FIGURE 2-1 A nuclear power plant generates electricity using a sequence of events.



How a Nuclear Power Plant Works

1. Energy released in the reactor core by the nuclear reaction heats the water in the pressure vessel to a very high temperature.
2. The superheated water is pumped from the pressure vessel into the steam generator.
3. The water is then converted into high-pressure steam.
4. After that, the steam is directed against a turbine and causes it to turn.
5. The turbine sets the generator in motion which generates electricity.

(from Holt Environmental Science)

Numbered steps are the easiest way to understand a written sequence. Most sequences you will study will not be written in this obvious way. Read the second passage, "The Water Cycle," and see if you can pick out the sequence of events described.

The Water Cycle

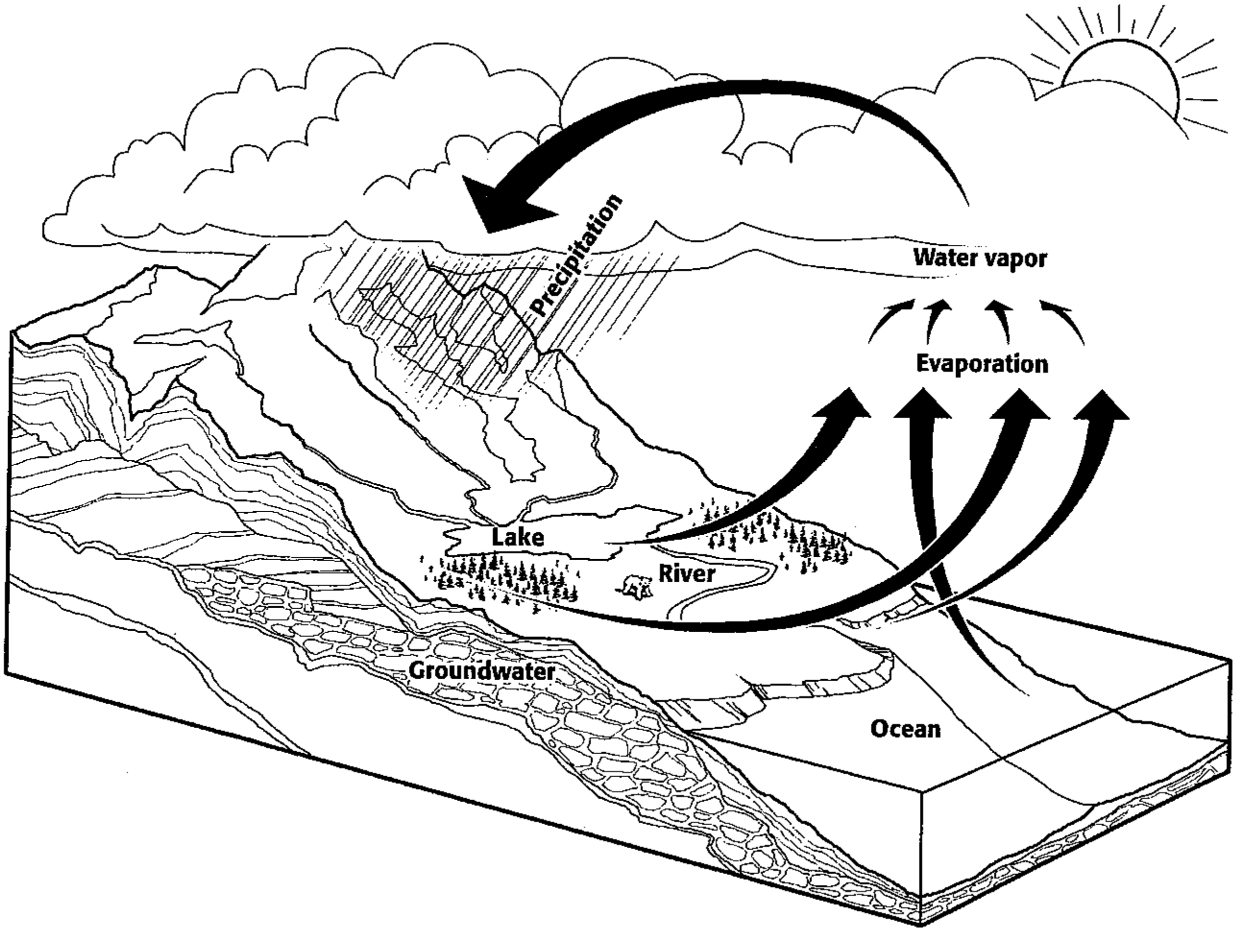
Water is the substance most essential to life. Fortunately, water is not usually destroyed; it just moves from place to place in the process shown in **Figure 2-2** on the next page. In this process, called the water cycle, water moves between the atmosphere and the Earth.

The sun provides the energy that drives the water cycle. Heat from the sun evaporates water from the oceans, from lakes and rivers, from moist soil surfaces, from the leaves of plants, and from the bodies of other organisms. As water vapor rises, it cools and expands. As it cools, it condenses and forms tiny droplets of water in the clouds. When the clouds touch the cold air, the droplets are released as rain, sleet, or snow. Because oceans cover most of the planet, most precipitation falls on the oceans.

The precipitation that falls on land may just evaporate again into the atmosphere. Or it may collect in streams and rivers that flow into oceans. Or the precipitation may soak into the soil. Water that soaks into the soil may be used immediately by plants, or it may seep down through the soil and rocks until it reaches a layer of rock and clay, called ground water. Then the process begins again and continues until the end of time.

(from Holt Environmental Science)

FIGURE 2-2 The Water Cycle



In order to fully understand the passage, you might want to break it up into a numbered list of events in chronological order. Any sequential passage can be turned into a numbered list of events resembling the first passage on how a nuclear power plant works. The following is an example of how the water-cycle passage might break down into a numbered list:

1. The sun heats water in oceans, lakes, rivers, moist soil, leaves of plants, and bodies of other organisms.
2. The water vapor rises in the atmosphere.
3. It cools and expands.
4. The water vapor condenses and forms tiny droplets in the clouds.
5. When the clouds contact cold air, the water falls to Earth as rain, sleet, or snow.
6. Water collects in oceans, streams, rivers, or ground water.
7. The cycle begins again.

Exercise 2 gives you the opportunity to practice breaking down a written passage into a chronological list of events.

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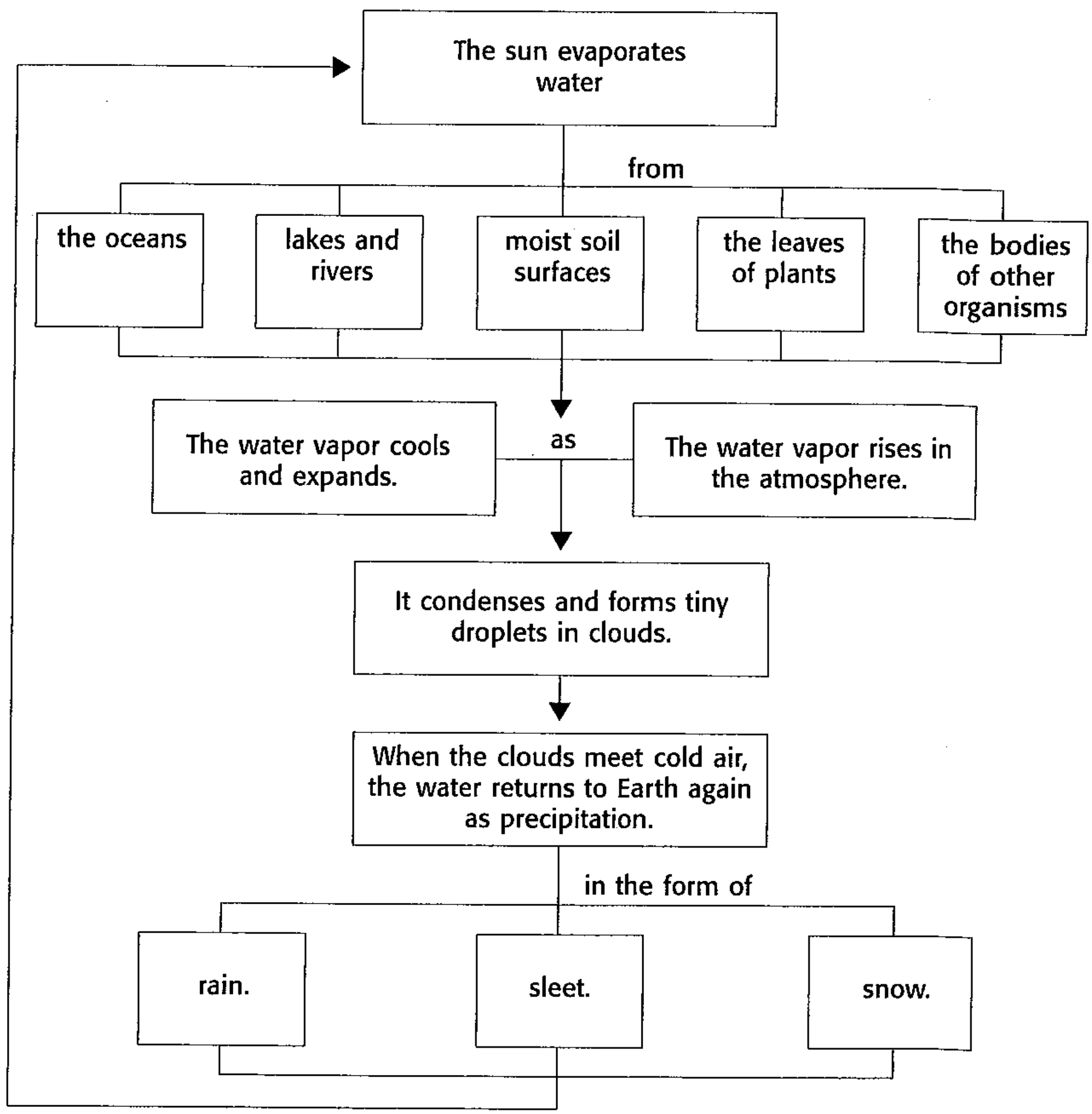
Notice in the passage on the water cycle that some of the steps in the sequence occur at the same time, or **simultaneously.** For example, the sun evaporates water from many sources at the same time. It can be difficult to envision steps occurring simultaneously. Making a diagram, such as a flowchart, can help you get all of the necessary information out of a complicated passage. **Figure 2-3** is an example of a flowchart that could be used to help clarify the information in the water-cycle passage. Exercise 3 allows you to practice turning a written sequence of events into a flowchart.

FIGURE 2-3 Flowcharts allow you to diagram events that happen simultaneously.



Exercise 2 **Chronological Lists**

Read the following passage and make a numerical list of the steps involved in the described process.

What Happens During Photosynthesis

Plant cells have organelles called chloroplasts. Chloroplasts contain chlorophyll, a green pigment. Chlorophyll absorbs most of the colors in sunlight, but not green. Plants look green because chlorophyll reflects green light.

The light energy absorbed by chlorophyll is used to split water into hydrogen and oxygen. The hydrogen is then combined with carbon dioxide from the air surrounding the plant to make sugar. Oxygen is given off as a byproduct.

(from Holt Science & Technology: Life Science)

1. ____

2. ____

3. ____

4. ____

5. ____

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Exercise 3 Simultaneous Events in a Process

Read the following passage and use page 26 to make a flowchart diagramming the events described in the text.

Where the Elements Come From

According to current theory, sometime between 12 billion and 16 billion years ago, the entire universe could fit on a pinhead. Then with unbelievable violence, the universe exploded, an event scientists named the big bang. Immediately after the big bang, temperatures were in the millions of kelvins. The temperatures were so high that matter could not exist, only energy could exist. As the universe expanded, it cooled. When the universe cooled to a few thousand kelvins, some of its energy was converted to matter in the form of electrons, protons, and neutrons. As the universe continued to cool, these particles formed the first atoms, almost all hydrogen but also some helium.

Over time, huge clouds of hydrogen accumulated. Gravitational attraction pulled the clumps of hydrogen closer and closer together. As the clouds became denser, pressures and temperatures at the centers of the hydrogen clouds increased and stars were born. In the high-temperature centers of stars, nuclear reactions took place. A nuclear reaction is a reaction involving protons and neutrons in the nuclei of atoms. In the nuclear reactions in the centers of the first stars, hydrogen nuclei fused with one another to form helium nuclei.
(from Holt Chemistry Visualizing Matter)

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CHAPTER 2 DESCRIBING TIME

2-3 General Time Markers

The following passage describes how the solar system formed.

Formation of the Solar System

About 4 billion to 5 billion years ago, shock waves from a supernova (a giant exploding star) or some other force caused a cloud of dust and gas to contract. The cloud of dust and gas that formed our solar system over time is called the solar nebula. When the temperature at the center of the nebula became hot enough, hydrogen fusion began and the sun was formed. About 99 percent of the matter in the solar nebula became part of the sun.

During a period of roughly 100 million years, the small bodies of matter in the solar nebula came together to form what are called planetesimals. Through collisions and the force of gravity, some of these planetesimals gradually joined to form much larger bodies called protoplanets. Eventually, the protoplanets condensed into our existing moons and planets.

(from Modern Earth Science)

Even though specific time markers come in the first sentences of each paragraph, you understand the sequence of events because the author uses many **general time markers.** These relate the time of one event to the time of another event. For example, you know that hydrogen fusion occurs after the temperature at the center of the nebula reaches a certain point. The author uses the word *when* to indicate the time at which hydrogen fusion occurs. *When* is a general time marker.

Table 2-2, on page 28, lists several different time relationships and lists some words and phrases that are used to indicate those relationships. **Section 2-2** dealt with sequences used to describe processes. You saw two different ways to include process time in a text: as a chronological list or as written text. In a chronological list, the numbers become time markers. These numbers can be cardinals (1, 2, 3, etc.), as they were in the first passage of **Section 2-2,** or ordinals, as shown in the short passage below.

The Scientific Method

First, ask a question. Second, form a hypothesis. Third, test the hypothesis. Fourth, analyze the results. Fifth, draw conclusions. Sixth, communicate the results.

(from Holt Science and Technology: Physical Science)

Table 2-2 General Time Markers

Words used at the beginning of an event	**Words used in a sequence**	**Words used for things that happened before other things**	**Words used for things that are happening simultaneously**	**Words used to indicate the end of an event**
First	after that	before	as	finally
At first	as soon as	but first	at the same time	at last
In the first place	first, second, etc.	by the time	during	the final
To begin with	next	prior to	while	last
To start	then		meanwhile	
At the beginning	when			
In the beginning	following that			
	subsequently			
	eventually			
	once			

There are other ways to present a sequence of events, steps, or activities. A chronological list can also be made using the letters of the alphabet instead of numbers. Time markers, such as *first, next,* and *then,* can put events in order. See Table 2-2 for more examples of time markers that can indicate a sequence. Maybe you can think of even more ways to write a passage in which a sequence of events is described.

Exercise 4 **Time and Sequence Words**

Read the following passage, and list the sentences or phrases containing time markers used to describe the sequence of events.

Cycles of the Universe

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

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

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

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

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

(from Modern Earth Science)

a. ______________________________

____

____

b. ______________________________

____

____

c. ______________________________

____

____

d. ______

e. ______

f. ______

g. ______

h. ______

i. ______

j. ______

k. ______

Exercise 5 Recalling Time Sequences

It is important not only to be able to read a passage and understand any time sequences described, but also retain the information in its correct chronological order. Without looking back through the chapter, number the sentences below in their proper chronological sequence. A few of the steps are already numbered for you. You must fill in the numbers for the rest.

_10_ The moons and planets come into being.

_____ Hydrogen fusion begins.

_1_ Shock waves from a supernova cause a cloud of dust and gas to contract.

_____ Small bodies of matter in the solar nebula come together.

_____ The sun is formed.

_____ The cloud of dust and gas form a solar system in the solar nebula.

_____ Planetesimals join together through collisions and gravity.

_____ Protoplanets are formed.

_3_ The temperature at the center of the nebula becomes very hot.

_7_ Planetesimals are formed.

Exercise 6 Fill In the Time Markers

Fill in the blank spaces in the passage below with appropriate time markers. If you need help, check back over the list of time markers in Table 2-2. Use as many different time markers as possible. The figure following the passage may help you establish the correct sequence of events.

Formation of a Coral Reef

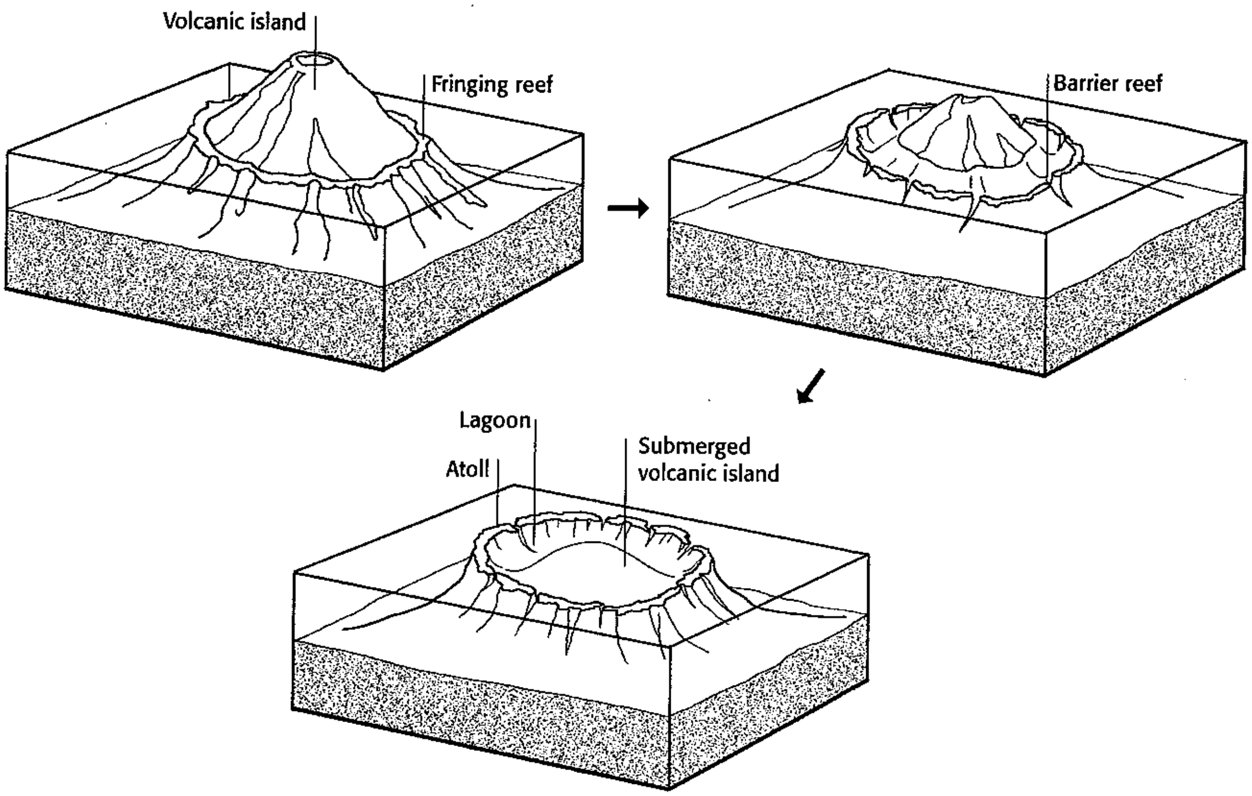
Corals are small marine animals that live in warm, shallow sea water. ____________________, a coral extracts minerals from the ocean water and uses them to build a hard outer skeleton. ____________________, corals attach to each other to form large colonies. ____________________, new corals grow on top of dead ones and form a coral reef, which is a submerged ridge made up of millions of coral skeletons.

Some coral reefs form around tropical volcanic islands. The coral colony grows in the shallow water near the shore. This type of coral reef around the coast of an island is called a fringing reef.

______________________ the ocean floor bends under the weight of the volcano, both the volcano and the reef sink.

______________________, the coral reef builds higher because the animals can live only near the surface of the water. The coral reef thus forms a barrier reef offshore around the remnant of the volcanic island. ______________________, the island disappears completely under water, leaving a nearly circular coral reef, called an atoll, surrounding a shallow lagoon.

(from Modern Earth Science)



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Exercise 7 Using Time Markers

Using at least five of the time markers from Table 2-2, write a paragraph describing what you did last weekend

2-4 Marked and Unmarked Patterns

Patterns indicating time relationships can be marked or unmarked. A **marked pattern** has a word or phrase to indicate the relationship. The passages you have read so far include specific or general time markers. The time markers *mark* the time patterns. **Unmarked patterns** do not have words or phrases to indicate the time relationship. For this reason, unmarked patterns are sometimes harder to detect and understand.

In the language of science, a marked pattern may be called **explicit:** it is stated specifically in writing or in speaking. An unmarked pattern is **implicit:** it is not stated but is **implied.** The reader has to infer, or guess, the time pattern or the relationship from the nature of the material. The following passage on how nerve impulses travel gives examples of both marked and unmarked relationships.

The Journey of a Nerve Impulse

A nerve impulse can travel only so far before it reaches the end of the axon. In most cases, neurons do not touch each other directly. They are separated by a tiny gap called a synapse.

[1] When a nerve impulse reaches the end of an axon, it must cross the synapse if the message is to continue. In most cases, a message is unable to "jump" from one neuron to another. Instead, the impulse is carried across the synapse by chemical messengers called neurotransmitters. When a nerve impulse reaches the end of the axon, neurotransmitters are emptied into the synapse. [2] The neurotransmitters diffuse across the synapse and bind to receptors in the membrane of the adjacent neuron.

(from Holt Biology Visualizing Life)

The sentence numbered (1) is a *marked* sentence. The time marker *when* explicitly states a time pattern. The sentence numbered (2) is *unmarked.* There is no time marker in sentence (2). You can assume that after the neurotransmitter is emptied into the synapse, it diffuses across the synapse to deliver the message or impulse, but this time relationship is implicit, or implied. Exercise 8 gives you additional practice in spotting marked and unmarked relationships.

Exercise 8 **Marked or Unmarked?**

Read the following passage and decide whether the numbered sentences are marked or unmarked. Write "marked" or "unmarked" next to the corresponding numbers on the lines provided. Then on the next line write the marker if there is one.

Solid as a Rock

You all know the phrase *solid as a rock.* Well, that phrase may be true for human time. But for geological time, rocks aren't solid at all. Or rather we can say that rocks change over time. There are three kinds of rocks: *igneous, sedimentary,* and *metamorphic.* Any of the three types of rock can be changed into another type. Various geological forces and processes cause rock to change from one type to another and back again. This series of changes is called the rock cycle.

[1] The process begins with the eruption of volcanoes and the cooling of magma. Magma is hot, molten rock, from the earth's interior. It is the parent material for all rocks. Magma is called lava if it cools at Earth's surface. [2] Magma that eventually cools and hardens forms igneous rock. [3] Once a body of igneous rock has formed, forces such as wind and waves break the rock into small fragments. Rocks, minerals, and organic matter that have been broken into fragments are known as sediment. [4] When the sediment deposits harden after being compressed and cemented together, they form sedimentary rocks.

[5] If the new sedimentary rocks are subject to tremendous pressure, extreme heat, and chemical processes, they can be changed into a third type of rock, called metamorphic rock. [6] If that heat and pressure become even more intense, the metamorphic rock will melt and form magma. [7] This magma may then cool and form new rock. What kind of rock–igneous, sedimentary, or metamorphic–will this new rock be?

(from Modern Earth Science)

1. ______________________

____

2. ______________________

____

3. ______________________

____

4. ______________________

____

5. ______________________

____

6. ______________________

____

7. ______________________

____

GLOSSARY

chronological time time that involves specific dates and times, for example, 1600 B.C.E or 8 A.M. (15)

explicit stated or indicated directly (34)

general time marker a word or phrase that indicates a time relationship (27)

implicit not stated but implied (34)

implied suggested but not stated directly (34)

marked pattern a time pattern that is indicated (or marked) by a time word or phrase (34)

process time time relationships that indicate a sequence (20)

sequence a series of steps leading to some end or result (20)

simultaneously existing or occurring at the same time (23)

specific time marker a word or phrase that contains a date or indicates the passage of time (15)

unmarked pattern a pattern whose meaning is not stated directly but is implied (34)