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DEPARTMENT OF EDUCATION  
BUREAU OF BASIC EDUCATION



# Integrated Science

**Science and Technology Textbook  
for First Year**

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**INTEGRATED SCIENCE**

**Science and Technology Textbook for First Year**

**Reprint Edition, 2006, 2009, 2012**

**Revised Edition, 2004**

**Revised Edition, 1991**

**First Edition, 1989**

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This edition was developed by the University of the Philippines National Institute for Science and Mathematics Education Development and printed and delivered for the Department of Education.

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Printed by



**Book Media Press, Inc.**  
21-E. Boni Serrano Ave., Q.C.,  
721-2803, 726-6647

in joint  
venture with



**Printwell, Inc.**  
38 Dansalan St., Mandaluyong City  
533-2388

**ISBN 971-570-124-8**

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## **To the Student**

In a world increasingly shaped by science and technology, “people need basic knowledge and skills if they are not to be alienated from the society in which they live, if they are not to be overwhelmed and demoralized by change, if they have to make those varied political, environmental, and ethical choices in which scientific discovery and its consequences are confronting us all” (UNESCO, 1983).

This statement means that science and technology are important to you, to your classmates, to your family, to everyone. They provide you with ways of making sense of the world systematically. They develop your scientific inquiry skills, values and attitudes, such as objectivity, curiosity, honesty, and habits of mind. All these are useful to your own personal development, future career, and life in general. These skills, values, and attitudes are likewise useful to the community where you belong, and are further useful to the country that you live in.

Science and technology allow you to explore and investigate natural phenomena, thereby enhancing your curiosity about your environment. Furthermore, science and technology provide tools needed to distinguish fact from fiction, to value evidence, and to respect and value the process of searching for truth.

In short, the study of science and technology enhances your scientific and technological literacy. Scientific and technological literates understand the nature of science and scientific knowledge; possess knowledge of science concepts and principles, and apply appropriate concepts, principles, laws, and theories in interacting with society and environment; use basic and integrated processes of science in solving problems, making decisions, and furthering understanding of society and the environment; and have positive attitudes towards science and its applications.

This book entitled Integrated Science is the first of a series of four on the interactions between and among science, technology, society, and environment. It will deepen your understanding of

basic science concepts in biology, chemistry, and physics as they apply to Earth and environmental phenomena, as well as problems, events and researches in space that have effects or applications on Earth. It will help you develop some skills that will serve as the foundation for lifelong learning about science and technology.

This book shows that science is an experimental endeavor. The activities allow you to observe materials, objects, and events, pose problems about these observations, make hypotheses, design a procedure to test your hypotheses, observe patterns, and draw conclusions. Some activities can be done at home to reinforce what you do in school or as a springboard for the next lesson. In addition, the activities take you from concrete experiences to some abstract ideas. You can do them inside the classroom, schoolyard, or any natural environment. The activities include the use of improvised apparatus and materials usually available in your homes and/or the community.

Developmental questions that have been consecutively numbered throughout each unit for easy reference are incorporated and strategically placed within the text proper and the activities. These developmental questions have been set in second color precisely to draw your attention and alert you to think and identify specific ideas or general principles which the lesson seeks to develop. As you answer these questions you will learn to be inquisitive about the way nature works.

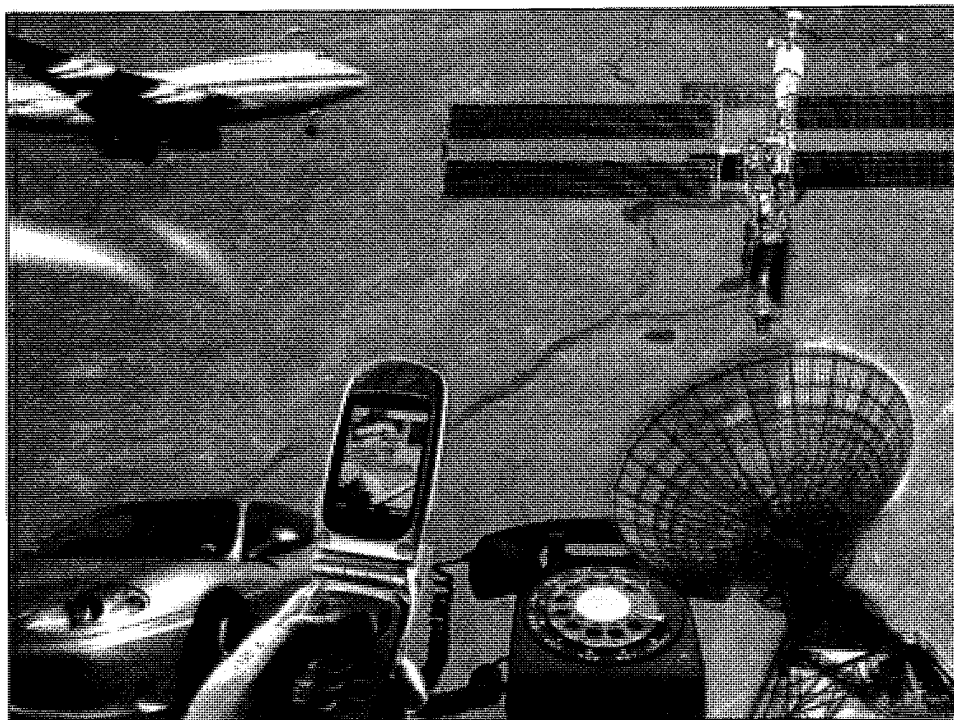
There are also end-of-unit questions, some of which are multiple choice while others are free-response. These assessment questions range from factual knowledge level to conceptual understanding and reasoning and analysis in accordance with the TIMSS (Trends in International Mathematics and Science Study) framework.

Enjoy learning about life and the environment through science and technology!



## Unit I

# Science and Technology in Your Life



Science and technology affect human beings and their way of life. They redefine clothes people wear, ways of getting food, types of dwelling, and even means of communication.

Scientists and inventors make these discoveries possible. What characteristics of scientists and inventors enable these individuals to succeed in their endeavors? How can one be a scientist or an inventor?

This unit will help you answer these questions and more. Specifically, you will review the science process skills or thinking skills learned in elementary school science. Mastery of these thinking skills will make science enjoyable. Moreover, they will help you understand better your immediate environment and the natural world.

## Lesson 1.1 Why Study Science and Technology

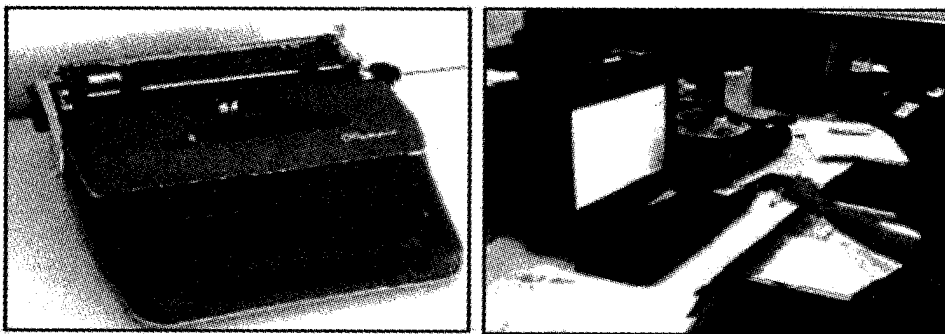
Look around. You see many interesting things. You certainly have questions about them. In science, we try to find answers to these questions and then ask more questions about what we sense around us. Science aims to look for answers to different events and phenomena, which occur naturally and those brought about by human activities.

Science is associated with technology often described as the “purposeful use of human knowledge of materials, of sources of energy, and of natural phenomena.” Thus, technology can be a product (pen and eyeglasses), a device (x-ray machine and laser printer), or a process (food preservation and sound-mixing).

Many times, technology evolves from scientific knowledge. For example, knowledge gained in science about electromagnetic waves led to the invention of the radio, the television, the karaoke—these things give us comfort or enjoyment. Technology may also serve as the springboard for more advanced studies in science. For example, the understanding of energy transformation (electrical and mechanical) in an electric motor led to the invention of the electric fan, the electric coconut grater, and the electric water pump.

The examples given above show that science and technology are always complementary. That is, principles developed in science are applicable to technology. And problems resulting from the use of some technological products are resolved by utilizing scientific knowledge.

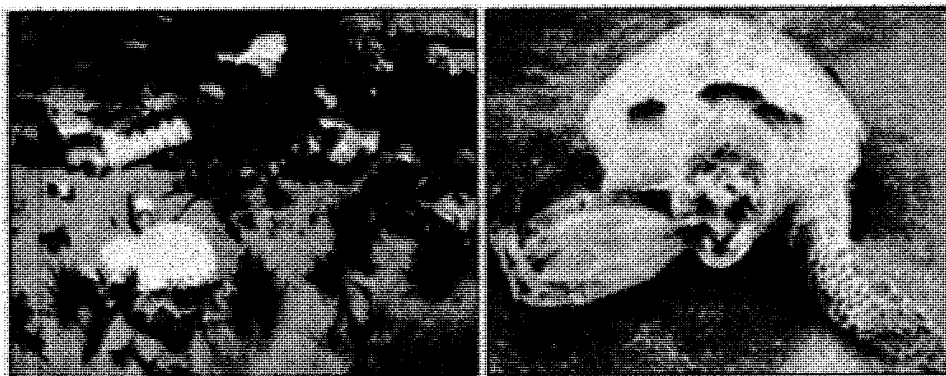
One of the best illustrations of the influence of science and technology in our lives is the use of the computer for storing information, word processing, running different programs, getting information from the Internet, disseminating information and communicating through the e-mail, and processing images taken by digital cameras.



*Figure 1.1 The typewriter used to be the most important equipment in an office. Today, the computer has taken its place because of its multiple uses.*

Different people have become dependent on computers. For example: astronauts depend on computers to direct their flights into space; bankers use computers to keep track of deposits and withdrawals; businessmen use computers to process orders or sort out inventories in warehouses. Even students, researchers, and teachers use computers to get information about specific topics and communicate them using power point and graphical presentations. People use e-mail to contact relatives and friends in other places.

The influence of science and technology in our lives appears to be unlimited. However, we have to be careful in using some of the latest products to prevent injuries, loss of life, or the eventual destruction of the environment. Some new medicines, for instance, may cause detrimental effects on the nervous system. Many pregnant women have given birth to stillborn babies because they took medicines that were not properly tested before they were made available in the market. Energy from the atom has been utilized to cure cancer patients but it has also been used as a weapon for war. Dynamite and fine nets have been used to get more food from the sea but without regard to the preservation of marine resources for future generations. Plastics have been widely used because they are cheap substitutes for glass and ceramics but their improper disposal has caused lots of environmental problems.



*Figure 1.2 Did you know that plastic materials found in bodies of water have caused the death of marine animals like the penguin?*

- Q1.1 Name two inventions that have made your life more enjoyable or comfortable.
- Q1.2 Which of these can you do without? Not do without? Explain your answer.
- Q1.3 Name three inventions which can be considered potentially harmful to life, property, and/or the physical environment.
- Q1.4 How can you reduce or avoid danger when you utilize these potentially dangerous products?

## **Lesson 1.2 Scientists and Inventors: Their Contributions to Society**

We have highly respected scientists and inventors in the Philippines and worldwide. What are their contributions to society? What makes them succeed in their work?

### **Some Filipino Scientists and Inventors**

Many of our countrymen have made significant contributions in science and technology in their attempt to solve some of our local problems. Our national hero, Dr. Jose Rizal, made many contributions to our country, including scientific and technological ones. A lover of nature, he recognized the existence of some animals which have not yet been scientifically identified and sent their specimens to Europe. European scientists then studied them and named them in his honor. Thus, we have *Draco rizali* (flying lizard), *Rachophorus rizali* (a toad), and *Apogonia rizali* (beetle with five horns). Further, it was during his exile in Dapitan when Rizal built the town's waterway system.

Dr. Alfredo Santos, one of our national scientists, greatly contributed to the development of herbal medicine. His studies covered indigenous plants and trees all over the country. While his research findings were not originally intended to supplant the medical services of rural health workers, those who live in the countryside can now avail of these alternative products. A recent discovery using herbal plants was made by Dr. Rolando de la Cruz. He discovered a topical herbal cream from cashew extract used to remove warts and herbal cream from a mixture of cashew and *kakawate* extracts used to remove basal cell carcinoma. Both won awards in the 2004 Moscow Archimedes Competition for Inventors.

In the 50s, Dr. Gregorio Zara invented the two-way television telephone and an airplane engine that ran on alcohol instead of aviation fuel. A few years back, Mr. Pablo Planas designed a gas saving gadget which when attached to a gasoline engine reduces a vehicle's fuel consumption by half and also reduces smoke emission by lowering toxic fumes due to its 100% efficient combustion.

Some inventions are useful in agriculture. Dr. Alberto Barrion of the International Rice Research Institute in UP Los Baños, developed an easy-to-use insect identification kits for rice pests and natural enemies and won him an Outstanding Scientist Award. Dr. Teresita Espino and her team from UP Los Baños developed a diagnostic kit for aflatoxin B1 detection in food and feed products. Dr. Saturnina Halos, a DNA (deoxyribonucleic acid) expert also became an entrepreneur for developing a biofertilizer which is environment friendly and easy to use.

In the field of medicine, Dr. Nina G. Barzaga and her team from the UP Manila College of Public Health discovered that eating *ampalaya* can improve the immune system. They also developed a vaccine from banana and tomato which can be used against salmonella poisoning. Dr. Lillian A. de las Llagas, also from UP Manila College of Public Health together with Dr. Mildred Oliveros of the College of Pharmacy, tested the efficacy of avocado extract as a mosquito larvicide. In addition, Filipino doctors and researchers from the UP Manila discovered a cure for prostate cancer, one of the leading causes of death among males in their 50s.

There are many Filipino scientists and inventors recognized here and abroad. You can get information about living men and women scientists and inventors from the Science and Technology Information Institute (STII) of the Department of Science and Technology (DOST) Bicutan, Taguig, Metro Manila. There are also articles in the internet about Filipino inventors and their discoveries.

Q1.5 Know more about scientists and inventors from your own town or region. Describe their contributions to science and technology.

### **Some Scientists and Inventors from Other Countries**

Who among the famous scientists from other parts of the world have you heard or read about? Do you know that Thomas Alva Edison (1847-1931, American inventor), discovered tungsten filament now used in incandescent lamps? Does the name Charles Goodyear (1800-1860, American inventor) ring a bell? You are right! By discovering rubber, those who manufactured vehicle tires later named the product after him. Archimedes (287-212 B.C. Greek mathematician, engineer, and physicist), discovered many things useful in the study of science such as the planetarium, the compound pulley, and the lever. He found a way to determine the volume of an irregularly-shaped solid.



*Figure 1.3 A caricature of Archimedes shows how he discovered the volume of an irregularly-shaped solid (his body), later used to solve for the specific gravity of the King's crown.*

In 1953, James Watson (American biologist) and Francis Crick (British biologist) figured out the structure of deoxyribonucleic acid (DNA). From 1990 to 2003, scientists of the US Department of Energy and the National Institute of Health accomplished the goals of the Human Genome Project. Among others, they were able to determine that there are approximately 30 000 genes in the human DNA and sequenced the 3 billion chemical base pairs of the human DNA. The accomplishments of the Project have great impact on medical-related studies. For example, some diseases that run in a family may now be detected and cured early.

Q1.6 Study the life story of one foreign scientist or inventor. Describe his or her contributions to science and technology.



*Figure 1.4 Young Edison was curious about the world around him. One day, he sat on a basket of eggs to see if he could hatch them. Do you think the eggs got hatched? Why or why not?*

## **Lesson 1.3 What Makes a Scientist?**

You may wonder how scientists in the Philippines and those from all over the world became successful. Let us read something about Thomas Alva Edison, the inventor of the incandescent bulb.

Edison once noticed that when electricity flowed through a piece of iron wire, the iron wire became red hot. The wire glowed brightly, but not bright enough to light a room. When he used a thinner piece of iron wire and allowed electricity to pass through, the wire glowed. But he wanted greater brightness. He tried other metals. Finally, he discovered that a thin piece of tungsten wire could actually glow so bright that it can easily light up a room.

But he also realized that the glow did not last long. After a few minutes, the wire burned to ashes. He wondered why. Since oxygen is needed in burning, he reasoned that if only the wire would not come in contact with oxygen, it would not burn. He, therefore, pumped out air

(containing oxygen) from a bulb using a machine. He then enclosed the tungsten wire in what he thought was already an oxygen-free bulb. He then tested the bulb. The wire glowed longer, but it also died out after a few minutes.

Edison tried pumping out more air and tested the bulb again. When the glow on the wire died out, he repeated his experiment, pumping out larger amounts of air and making sure no air entered the bulb. This was his way of finding out whether the length of time before the wire ceased from glowing was dependent on the amount of air present in the bulb. He repeated this activity over and over again, getting many bulbs busted in the process. But he did not lose hope. He continued with the experiment. Each time, the wire glowed brighter and longer. Finally, the tungsten glowed steadily. Edison knew then that he had succeeded. He had invented the incandescent light bulb.

Q1.7 Which of the following traits and attitudes helped Thomas Alva Edison succeed in his scientific endeavor?

- A scientist is curious. He or she asks questions. He or she is eager to find the answers to his or her questions.
- A scientist is a careful worker. He or she makes his or her observations carefully and accurately.
- A scientist is thorough. He or she avoids rash judgment. He or she does not accept a statement as a fact unless it has been well tested. He or she weighs evidence carefully before making a conclusion.
- A scientist believes in the tentativeness of science. He or she believes that ideas may change if evidence shows them to be wrong.
- A scientist is a critical thinker. He or she believes that nothing happens without a cause. He or she does not believe in superstitions.
- A scientist is fair-minded. He or she is not biased or prejudiced. He or she does not allow his or her judgment to be influenced by his or her likes or dislikes.
- A scientist is open-minded. He or she respects the ideas and opinions of others, even if they are contrary to his or her own.

Not all the traits listed above may be present in one person. Later, you will read about the life of other scientists whose traits and attitudes differ from Edison's life story.

Many young boys and girls like you have good ideas and attitudes. In fact, many of you may be "scientists in the making." Some students have already participated in science fairs and contests here and abroad, occasionally showing off local inventions.

For example, in 1985 Lani Rose Mateo, then a student of the Philippine Science High School (PSHS), won first honorable mention in the International Science and Engineering Fair (ISEF), the world's most prestigious science forum for the youth, for her experiment on the use of mold extracts to hasten clotting or coagulation and improve the taste of milk processed into cheese.

In 1998, a group of students from Sorsogon National High School led by Jessica Villamor won the fourth Grand Award for their project entitled "Parasitism of *Trichogramma chilonis* Ishii with Selected Lepidopterous Pests." *T. chilonis*, a parasitic wasp, was found to prefer tomato fruitworm, thus making *T. chilonis* a useful biological control agent against the worm.

Karen Christine Braganza of Cayetano Arellano High School reaped accolades for being the only two-time participant to the ISEF. In 1999, her project on the use of mine tailings as an alternative material for pottery and earthenware won the third grand prize in the environmental category while in 2002 her project, Bioglass Ceramics Using Lahar (or use of lahar for making bone implants), attracted attention in the medical field.

In 2003, Efrellene Galula of Agusan del Sur National High School won a Special Award for her research "Antibacterial Agent from the Midgut of Cattle Leeches."

Every year, Filipino high school students who are sent to the ISEF competition bring home awards for their research projects. The list of winners and their projects can be downloaded from the website of the Science Education Institute Department of Science and Technology (<http://www.sei.dost.gov.ph/intel-philsiencefair/archive.html>.)

For now, read and find out how Dario, a first year high school student, acted like a scientist himself. See if he exhibited traits and attitudes similar to Edison's.

One day, Dario saw his grandmother gather an herb called *makabuhay* from their backyard. He followed her into the kitchen and asked what she was about to do with the herb. *Makabuhay*, his grandmother said, is often used to heal wounds. She said that she would cook the herb in coconut oil and then use it as a poultice on a wound on her leg.

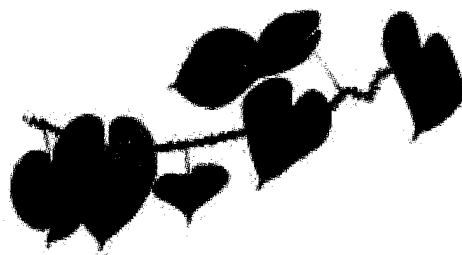


Figure 1.5 Makabuhay (*Tinospora miers*) (Source:[http://www.bwf.org/balikas/2003/12/1a\\_03.shtml](http://www.bwf.org/balikas/2003/12/1a_03.shtml))



Later, Dario noticed that the poultice did not stick long enough on the wound. It either dripped or dried up and peeled off. His grandmother had to apply the preparation repeatedly. After five days, the wound healed. Dario thought that the wound would have healed faster if the poultice had stuck to the wound a little longer. His inquisitive mind began its task of finding a way to make the poultice stay on the skin longer.

Dario recalled that when melted candle dripped on the skin and cooled, it stayed in place. He then considered mixing melted candle wax into the oily poultice to find out if it could be made to stay longer on the wound. He told his grandmother about this and was further told that the herbal preparation could be easily applied while still bearably hot.

Subsequently, they experimented on the preparation only to find out that when it cooled off, it soon hardened and was soon difficult to apply.

In school, Dario consulted his science teacher. She suggested that he try using beeswax instead of candle wax because beeswax is softer. At home, Dario eagerly applied heat to the oily herbal medicine and gradually mixed in the beeswax. The result was a substance that managed to remain soft even while cooling off. He called this an ointment. This soft ointment would surely stay longer on the skin when applied, he cheerfully concluded.

He then proceeded to test this assumption by recommending its use to some persons who had skin disorders. At the same time, he allowed others to use his grandmother's oil preparation. He advised his "patients" to apply the recommended medicine using the same time interval and applying the same amount each time.

He diligently kept a record of the progress of his "patients." Soon he noted that the skin disorders treated with the softer mixture healed faster than those treated with his grandmother's preparation.

On the recommendation of his class, Dario entered his study as an investigatory project in his school's Science Fair and won First Prize.

- Q1.8 What was Dario's study problem?
- Q1.9 What initial observations prompted him to study the said problem?
- Q1.10 What factors did he consider?
- Q1.11 What plans of action did he think of?
- Q1.12 Which plan of action did he finally choose? Why?
- Q1.13 What particular traits of a scientist did Dario show when he did his study on herbal ointment?

Dario's experiment may be too simple and ordinary, but he solved his problem in a systematic or logical manner. He followed the scientific method. Certainly, this is how scientists think and do their work.

## Lesson 1.4 Science Is Not Just for Scientists

Scientists ask questions about the things they observe. Do you also ask questions about what you see around you? Do you make an observation about objects, events, and phenomena and find out what patterns or trends are displayed? Whenever you ask questions and gather data about these objects and events, you are acting like a scientist. A scientist has a keen sense of observation and a logical way of gathering, organizing, and processing information. They use these basic process skills to guide them in finding solutions to problems.

Perform the activities that follow and review the basic process skills. Even if you will not become a real scientist, acquisition of these skills will help you solve laboratory or real-life problems, as well as enjoy learning science.

### Making Observations

#### Activity 1.1 How Keen an Observer Are You?

##### Materials

hand mirror

pencil and paper

##### Procedure

1. You see yourself in the mirror many times during the day. How well have you seen and observed your face? Find out by answering the questions below.
  - a. Are your eyes below, above, or in line with your ears?
  - b. Is your face square, oblong, or heart-shaped?
  - c. Do your earlobes have the same shape?
  - d. Are your eyelashes straight or curly?
  - e. Do you have a birthmark on the face?
  - f. Which is thicker, your upper or lower lip?
  - g. How many moles are there on your face?
  - h. When you wrinkle your brow, how many deep horizontal lines are formed on your forehead?
  - i. How many pockmarks are there on your face?

Exchange answer sheets with your nearest classmate. Ask your classmate to check your answers. Do the same for him or her.

How well did you score? If you were able to answer at least seven questions correctly, you are a good observer.

Many people do not see what they look at. Only a few can observe well. It is because they have been so used to seeing things in a particular order (like the parts of the face) that they do not take notice of little details anymore. Making observation means using one or more of our senses to find out about objects or events. An observation is a fact learned directly through the senses of sight, touch, hearing, taste, and/or smell.

Remember these tips when making observations.

1. Use as many senses as you can. Never taste unless you are told to do so.
2. When you pick up something or when you are watching an event, think about how you can use your senses to get information about that object or event.
3. Describe only what you observe directly through your senses.
4. Take note of changes. Include observations before, during, and after the change.

## Estimating and Measuring

In Activity 1.1, most of the guide questions asked you to observe your face qualitatively. In questions 1g to 1i, you were asked to quantify the things being observed. Quantitative observations make your description about objects or events more accurate. When you collect data for mass, length, temperature, or pressure, you have to use measuring instruments. For example, to measure the growth of plants, you need to use a ruler or count the number of leaves of the plant over a period of time. If you need cans or materials for an experiment, you need to specify the sizes of the cans or the length, width, and thickness of the materials. What problems may occur if the sizes of the needed materials are not known?

In the same way, the police may easily identify and apprehend a robber or kidnapper if a witness can accurately describe the suspect. The description usually includes not only how he looked and what identifying facial marks he has, but also his approximate age, height, and body-build.

Did you know that people long ago measured length simply by using body measurements like *dali*, *dangkal*, *dipa*, and *talampakan*? See Figure 1.6.

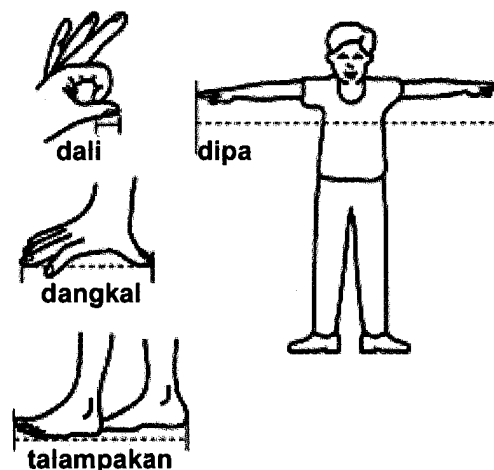


Figure 1.6 Body parts used for measurement

Q1.14 What problems do you think were encountered in using body parts as units of measure?

Q1.15 Why do you think these problems arose?

Do Activity 1.2 to check your answers.

### Activity 1.2 Measuring Using Body Parts

#### Material

ruler

#### Procedure

1. Measure the length and width of your book using your *dali*. Record your measurements in a table similar to the one below.

	Length ( <i>dali</i> )	Width ( <i>dali</i> )	Length (cm) (ruler)	Width (cm) (ruler)
Your measurement				
Family member's measurement				

2. Ask a member of your family to measure the same book using his or her *dali*. Enter his or her measurements in the same table.
  - a. Compare the two measurements.
  - b. Write down what you observe.
3. Repeat the activity with both of you using a ruler. Record your readings in centimetres. Tabulate your measurements.
  - c. Compare the results of the measurements using the *dali* and the ruler.
  - d. Write a conclusion based on the results.

Now you know why it is important to use a standard measuring device when making observations instead of using body parts. People have different arm lengths. Thus, when a long-armed customer buys a piece of cloth from a short-armed seller, there will be disagreements.

In the Philippines, the Bureau of Standards determines the standards or official norms of measurement to be used. The acceptable standard of measurement at present is the Metric System. This is considered the International System of Unit (Système Internationale d'Unites or SI units). Presidential Decree No. 187 signed in 1978 directs the use of the Metric System and abolished the use of the English System of

measurement in both industry and commerce. Thus, the gallon, pint, and the customary units like picul, quintal, and *ganta* are no longer used.

How convenient is it to use the Metric System? Examine Table 1.1 to help you answer questions on conversion of units.

**Table 1.1 Standard Units of Measure ((Metric System))**

<b>Length</b>	10	angstrom (Å)	=	1	nanometre*
	1 000	nanometres (nm)	=	1	micrometre
	1 000	micrometres (µm)	=	1	millimetre
	10	millimetres (mm)	=	1	centimetre
	10	centimetres (cm)	=	1	decimetre
	1 000	millimetres	=	1	metre
	100	centimetres	=	1	metre
	10	decimetres (dm)	=	1	metre
	10	metres (m)	=	1	decametre
	10	decametres (dkm)	=	1	hectametre
	10	hectametres (hm)	=	1	kilometre
	1 000	kilometres (km)	=	0.1	megametre
	<b>Mass</b>	1 000	milligrams (mg)	=	1
10		grams (g)	=	1	decagram
10		decagrams (dkg)	=	1	hectogram
10		hectograms (hg)	=	1	kilogram
<b>Area</b>	100	square millimetres (mm <sup>2</sup> )	=	1	square centimetre
	100	square centimetres (cm <sup>2</sup> )	=	1	square decimetre
	100	square decimetres (dm <sup>2</sup> )	=	1	square metre
	100	square metres (m <sup>2</sup> )	=	1	are
	100	ares (ar)	=	1	hectare
	100	hectares (ha)	=	1	square kilometre
<b>Volume</b>	1 000	cubic millimetres (mm <sup>3</sup> )	=	1	cubic centimetre
	1 000	cubic centimetres (cm <sup>3</sup> )	=	1	cubic decimetre
	1 000	cubic decimetres (dm <sup>3</sup> )	=	1	cubic metre
	1 000	cubic metres (m <sup>3</sup> )	=	1	cubic decametre
	1 000	cubic decametres (dkm <sup>3</sup> )	=	1	cubic hectometre
	10	millilitres (mL)	=	1	centilitre
	10	centilitres (cL)	=	1	decilitre
	10	decilitres (dL)	=	1	litre
	1	litre (L)	=	1	cubic decimetre
	10	litres	=	1	decalitre
	10	decalitres (dkL)	=	1	hectolitre
	10	hectolitres (hL)	=	1	kilolitre
	1 000	litres	=	1	kilolitre
	1	kilolitre (kL)	=	1	cubic metre

\*Spelled meter in the United States only.

At present, certain units of measure which are not part of SI are still widely used. Some of these are: hour, kilowatt-hour, cup, or tablespoon. Some units which are most commonly used are:

- Length - kilometre (km), metre (m), centimetre (cm), millimetre (mm)
- Area - square metre (m<sup>2</sup>), hectare (ha)
- Volume - litre (L), millilitre (mL), cubic metre (m<sup>3</sup>)
- Speed - kilometres per hour (kph)
- Mass - kilogram (kg), gram (g)

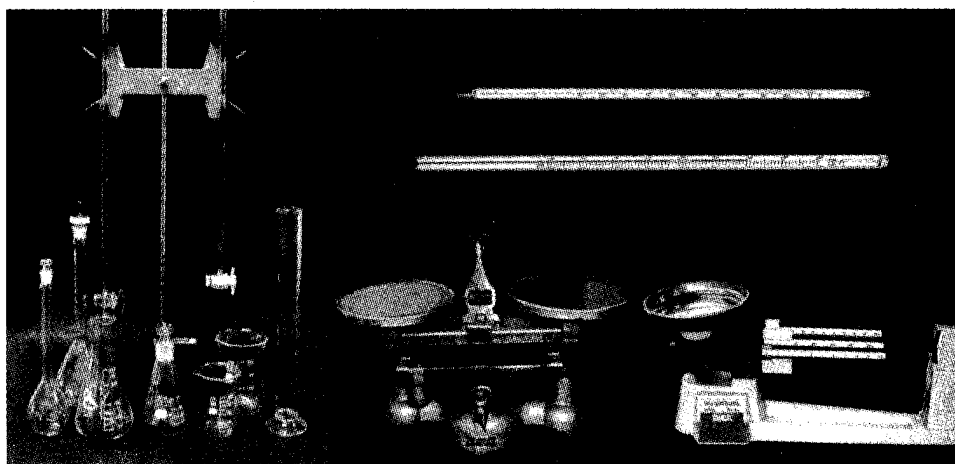
Refer to Table 1.1 to answer the following questions:

- Q1.16 How many millimetres are there in a metre?
- Q1.17 How many metres are there in a kilometre?
- Q1.18 How many cubic centimetres are there in one litre?
- Q1.19 How many milligrams are there in one kilogram?
- Q1.20 How are the units related to one another?

Metric units are given in multiples of ten (hundred, thousand, etc.). It is relatively easy to convert one unit to another.

- Q1.21 If your favorite basketball player is 1.8 metres tall, how will you record his height in centimetres?
- Q1.22 A fruit juice can contains 200 mL. How many cans are needed to prepare 2 L of fruit juice?
- Q1.23 A dozen medium-sized eggs have a mass of about 650 grams. How many kilograms is this? What is the average mass of one egg in kg?

Are you familiar with the instruments in Figure 1.7? Study them one by one.



*Figure 1.7 Some common measuring instruments. Where do we use each instrument? Do you know how to use them properly?*

The instruments used for actual measurements are calibrated against an accepted scale based on a standard measurement. The next activity will help develop your skills in measuring and reading scales.

### Activity 1.3 Using Standard Measuring Instruments with Precision and Accuracy

#### Materials

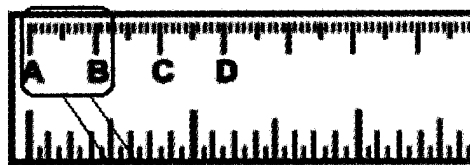
platform or triple beam balance  
graduated cylinder with water

block of wood  
ruler

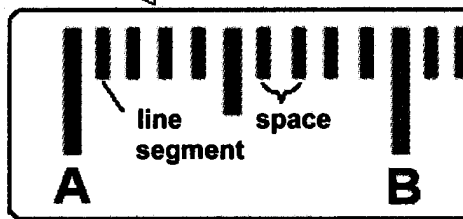
#### Procedure

##### Part A

1. Take a standard ruler. Put marks A, B, C, and D on points as indicated.



- How many equal spaces are there from A to B?
- Note that each space is bounded by two line segments. What does each space represent in fraction form?



- How many millimetres are there in 1 centimetre?
- How many centimetres are there from A to C? from A to D?
- What is the length from A to C in millimetre? from A to D in millimetre?

2. Take a block of wood. Measure its length (L), width (W), and height (H) in mm using the ruler. Do this three times and record the measurements in table form.

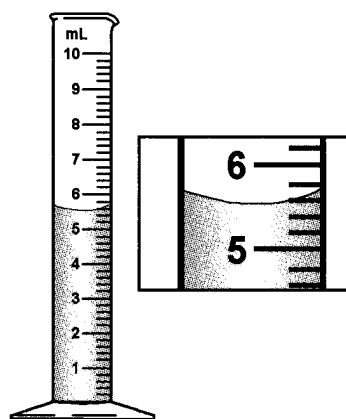
- Are your measurements the same for the three trials? If not, where did the error come from?
- How did you report the measurements—two, three, or four digits?
- Why did you report them that way?
- The volume of a regularly-shaped solid is the product of its L, W, and H. What would be the unit for volume? How will you report the unit for volume?
- What is the volume of your block of wood? Use proper units.

### Part B

3. Take a platform or triple beam balance. Your teacher will teach you how to use the balance.
4. Measure the mass of the block of wood.
  - k. How many digits will you use to report the mass of the block of wood? Why will you report it that way?
  - l. What is the mass of your block of wood in grams? in kilograms?

### Part C

5. Get a graduated cylinder.
  - m. What is the maximum capacity (or volume) that can be accurately measured by the cylinder?
  - n. Note that each mL is divided into five equal spaces. What does each space represent?
6. Put any amount of water in the graduated cylinder. Read the lower meniscus.
  - o. Take note that each space is bounded by two line segments. What does the value of each space represent in fraction form?
  - p. What is the volume of the water? In reporting the volume, how many significant figures should you use?



Remember that there is no such thing as a perfect measurement. Each measurement contains a degree of uncertainty due to the limits of instruments and the people using them. When measuring something, you are expected to follow the same procedure that scientists follow. Each measurement should be reported using significant figures, that is, with some digits that are certain, plus one digit with a value that has been estimated.

For example, in Part A of Activity 1.3 you used a ruler that has smaller spaces which allow you to read the length up to the nearest millimetre. Therefore, the length should be reported to the nearest millimetre (i.e., 28.5 mm). This would show that the value 28 mm is certain and you estimated the final digit because the wood was about half way between the values 28 and 29. Your ruler allows you to read the length in cm, so the correct value would be 2.85 cm. This means that the value 2.8 cm is certain and the final digit is estimated.



There are two concepts that have to do with measurements: accuracy and precision. The accuracy of the measurement refers to how close the measured value is to the true or accepted value. Precision refers to how close together a group of measurements actually are to each other.

For example, if you used a balance to find the mass of a known standard 50.00 g mass, and you got a reading of 38.55 g, your measurement would not be very accurate.

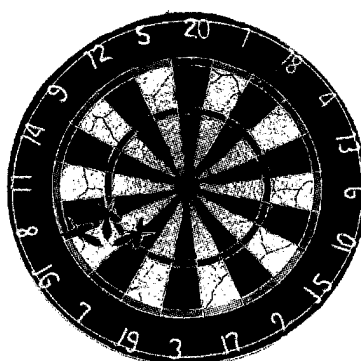
One important distinction between accuracy and precision is that accuracy can be determined by only one measurement, while precision can only be determined with multiple measurements.

Precision has nothing to do with the true or accepted value of a measurement, so it is quite possible to be very precise and totally inaccurate. In many cases, when precision is high and accuracy is low, the fault can lie with the instrument. If a balance or a thermometer is not working correctly, they might consistently give inaccurate answers, resulting in high precision and low accuracy.

A dartboard analogy (Figure 1.8) can help you understand the difference between accuracy and precision. Imagine a person throwing darts, trying to hit the bull's-eye. The closer the dart hits the bull's-eye, the more accurate his or her tosses are (a). If the person misses the dartboard with every throw, but all of their shots land close together, they can still be very precise (b).



(a) Accuracy and precision



(b) Precision

*Figure 1.8 When making measurements, you can have high precision but low accuracy. How is this possible?*

You must strive for both accuracy and precision in all of your laboratory activities. Make sure that you understand how each instrument works, take each measurement carefully, and recheck to make sure that you have precision. Without accurate and precise measurements your calculations, even if done correctly, are quite useless.

Skill in reading scales is important in obtaining correct measurements when using any standard equipment. You can convert one unit to another using the Metric System.

What have you learned so far? Observations may be qualitative or quantitative. Qualitative observations require use of appropriate words, adjectives, or other descriptors. Quantitative observations require the use of standardized measuring instruments such as ruler, balance, graduated cylinder, protractor, thermometer, and stopwatch. Nonstandard items like paper clips, cups, or coins can also be used.

To make accurate measurements remember the following:

1. Estimate the measurement. Making estimates will give you a frame of reference.
2. Compare your estimate using standard or nonstandard units.
3. Read the value shown in the instrument as accurately as possible.
4. Calculate for derived measurements.

## **Classifying**

What objects and events do you see around you? How are these objects or events similar? How are they different? Scientists group objects and events by first observing similarities and differences among objects and events and then grouping them according to common characteristics or scheme. Objects and events can be classified using one or multistage schemes. For example, books in the library are classified according to subjects. Animals are classified based on the food they eat, or skin cover, or habitat, or number of legs.

How good are you at classifying objects or events? Follow these tips:

1. Observe a set of objects or events. Think of their properties or characteristics.
2. Divide the set into two or more groups based on one observable property.
3. Divide the objects or events based on a second observable property.
4. Repeat number 3 using another observable property.
5. Show the classification using a diagram.

An example of a classification of solid waste is shown in Figure 1.9.

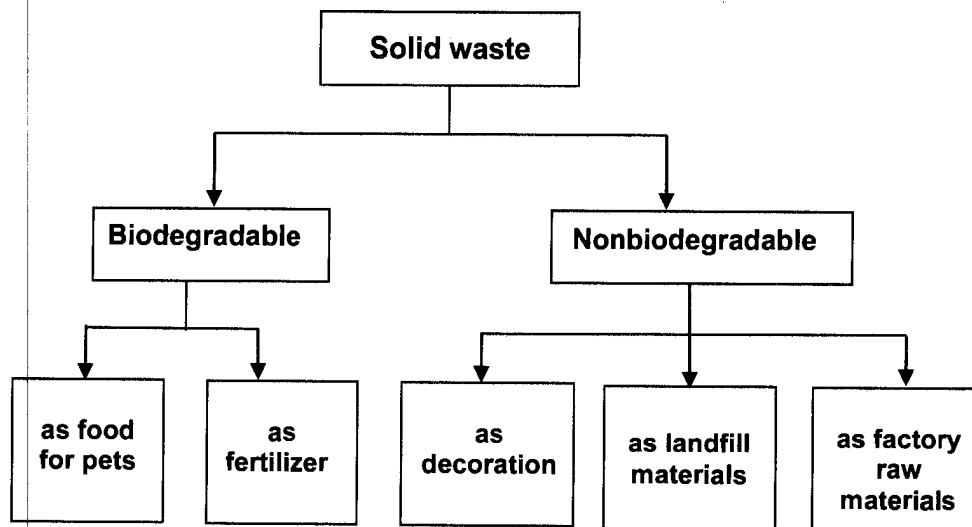


Figure 1.9 Classifying solid wastes according to biodegradability (level 1 and level 2)

Review your skills in classifying by doing the activity that follows.

#### Activity 1.4 Grouping Objects and Events

##### Materials

different objects

##### Procedure

1. Visit a garden. Observe the leaves of different plants without removing them from the plant.
  - a. Into how many ways can you classify the leaves?
  - b. What is the basis for each grouping?
  - c. Make a diagram to show the groupings.
2. Study the objects or contents of the containers distributed by your teacher. Group them in as many ways as you can in 10 minutes. Use the measuring instrument given, if possible.
  - d. Into how many ways were you able to classify the objects?
  - e. What is the basis for each grouping?
  - f. How did the instrument help you in making the classification?
  - g. Make a diagram to show the different groupings.

3. You are familiar with the following environmental phenomena: earthquake, volcanic eruption, flooding, erosion, tides, solar eclipse, and meteor showers.

- h. Using all the phenomena, group them in two ways.
- i. Explain the basis for such grouping.
- j. What phenomenon was difficult to classify? Why was it difficult to classify?
- k. If air pollution were added to the list, in which group would you put it?

What did you learn when classifying objects? Consider the leaves you observed. When classifying the leaves, did you compare their color, size, shape, thickness, smell, presence of thorns or hair, and other properties?

How about the objects? Did you observe some or all of the following properties: color, size, luster, conductivity, heaviness, reaction in water or acid, and number of components in the container?

Did you group the environmental phenomena based on whether they are natural occurrences, or whether they are due to human activities, or whether they are land-based, water-based, or observed in the sky?

If you did all these, you have made a good classification scheme.

## **Making Inferences**

By now you can generalize that an observation is a personal experience obtained through one or more of the senses. Based on these experiences, you can make inferences. We infer when we use our past experiences to draw conclusions and make explanations about objects or events not observed. For example, when we see a colorless liquid we say, "It looks like water." This statement is an inference because we know that not all colorless liquids are water.

To make good inferences remember the following:

1. Observe an object or event very carefully.
2. Based on past experience, think of several inferences.
3. Decide which new observations would support these inferences.
4. Make new observations to determine if each of the inferences is an acceptable explanation.

You can make more than one inference to explain an observation. For example, one morning you observed that your best friend came to class with red eyes. Based on past experiences about red eyes, you infer that she cried last night, or she rubbed her eyes with dirty fingers, or she has sore eyes. To check which inference is correct you have to ask your friend what happened or make observations to determine which inference has an acceptable explanation.

Do the next activity to practice inferring skills.

### **Activity 1.5 Inferring**

#### **Materials**

five cans provided by the teacher  
leaves

#### **Procedure**

##### Part A

1. Shake each can. Describe the sound produced by each can.
2. Infer and draw what you think is inside each can.
3. Open each can. How many of your inferences were correct?
4. Describe how shaking the cans helped you infer the object inside each can.

##### Part B

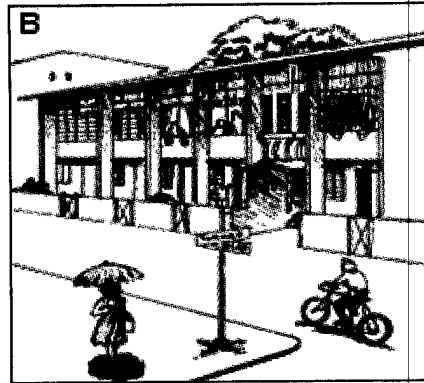
5. You are given leaves—some are damaged with holes.
  - a. What do you think caused the holes in some leaves?
  - b. Do you think the holes were made by one kind of organism? Why or why not?
  - c. Why do you think are the other leaves hole-free? Give two inferences.
  - d. Do more observations to check the inferences you gave to answer questions b and c. (This may take more than one observation period.)

Making an inference means deriving additional information from observations by relating them to experiences or by reasoning out logically. In the next activity, you should be able to differentiate casual observations from inferences.

### Activity 1.6 Differentiating Observations from Inferences

#### Procedure

Study pictures A and B.



Indicate which of the statements below are observations and which are inferences by marking the appropriate column with a check mark.

Statements for Picture A	Observation	Inference
Example: The man is wearing a hat.	✓	
1. The man is leading the carabao with a rope.		
2. There is a haystack in the field.		
3. The field is planted with rice.		
4. It is about 5:00 p.m.		
5. It is rainy season.		
6. The man is tired.		

Statements for Picture B	Observation	Inference
Example: It is about 12:00 noon.		✓
1. The girl has an umbrella.		
2. The shadows are short.		
3. Some windows in the building have curtains.		
4. Many people are working in the building.		
5. The building is sturdy.		

If you are a keen observer, you can give more specific details about a picture, an object, or event. Based on your experience, you can safely deduce what is happening or what has happened in a certain place or infer the function and/or use of an object.

## Interpreting Data

When you read newspapers, magazines, or books, some data are tabulated or graphed. At first glance, the given set of information is not familiar to you. But you can get meaning from such data if you could analyze the data well.

The next activity will help you review your skills in interpreting data in a table and in a graph.

### Activity 1.7 Interpreting Data

#### Procedure

##### Part A. Tabulated Data

1. Study the table on the right.

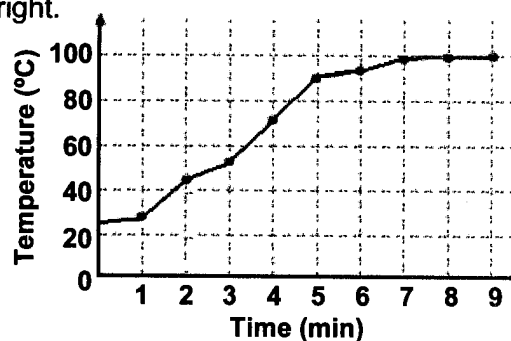
- a. What does the table show?
- b. What is the unit of measurement used to measure time?
- c. What is the unit of measurement used to measure the distance traveled by the car?
- d. What will be the distance traveled by a car after 90 min?
- e. Knowing that speed is a measure of distance traveled per unit time, how is the speed of the car expressed?
- f. What kind of road do you think is the car traveling on—straight or zigzag? How do you know?

Time (min)	Distance Traveled by a Car (km)
0	0
15	25
30	50
45	75
60	100
75	125

##### Part B. Graphed Data

2. Study the line graph at the right.

- g. What is represented by the horizontal axis? the vertical axis?
- h. What is the starting temperature?



- i. Describe the line graph for the first seven minutes. What does this line mean?
- j. Describe the line graph for the last three minutes. What does this line mean?
- k. What general information can you derive from the graph?
- l. Can you tell what happens in certain intervals of time? Why or why not?
- m. What is the temperature after 5.5 minutes?
- n. What would be the direction of the line graph if the energy supplied is extended five minutes longer?

The information presented in Part A of Activity 1.7 enabled you to determine the distance traveled by a car at specific times. Because the distance traveled by a car at a given time was constant, you were able to predict the distance it will travel after 90 minutes. You inferred that the road the car was traveling on was straight because the speed was the same given any time interval.

In Part B, the line graph showed that the temperature changed when energy was supplied to water for a given period. During the first seven minutes, the water temperature steadily rose as shown by the line, slanting upward. In the last three minutes, the water temperature did not change as water boiled at  $100\text{ }^{\circ}\text{C}$  (normal boiling point of water at one atmospheric pressure). The temperature remained constant as indicated by a straight horizontal line on the graph. Therefore, you can generalize that the continued application of energy to boiling water does not increase the temperature of the water beyond  $100\text{ }^{\circ}\text{C}$ .

The graph can also tell what happens in certain intervals of time. For example, you can determine the temperature after 3.5 minutes of supplying energy to the water. To do this, draw a broken line vertically upward, starting between time points 3 and 4 minutes, until the graph line and broken line intersect. Then mark the point where the lines intersect. From the intersection, draw a horizontal line to the left until it touches the line which gives the temperature reading. Thus, after 3.5 minutes, the temperature of the water could be about  $62\text{ }^{\circ}\text{C}$ . Thus, you can approximate the temperature in a given time interval of supplying energy.

Q1.24 Explain in one or two sentences how tabulated or graphed data help you learn new information or recall concepts already learned.

Take time out to reflect. After doing Activities 1.1 to 1.7, do you think you have gained more confidence in practicing basic process skills in science? Remember that these are the same skills useful in everyday life, especially in analyzing how science and technology affect your everyday life. Figure 1.10 presents the basic process skills.



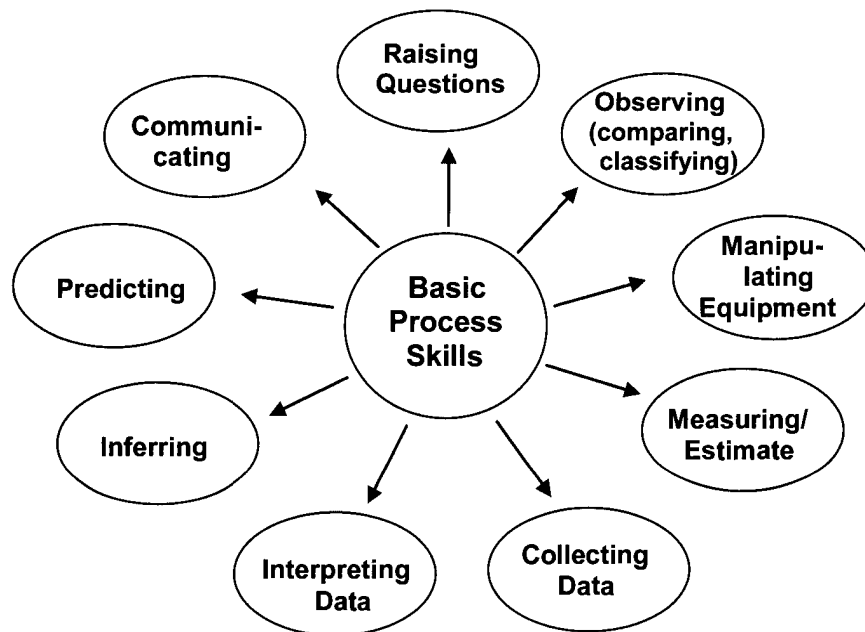


Figure 1.10 The circular presentation of the basic science processes or thinking skills means that they can be used in any sequence in an activity.

## Lesson 1.5 Traditional Beliefs and Practices: Do They Have Scientific Bases?

A scientific mind acts from sound reasoning. But some people act on mere impulse and old habit. Others simply repeat what others are doing. Others follow some old beliefs and practices. Although some beliefs and practices have scientific bases, most are merely superstitious in nature and have no scientific value at all.

Consider one common belief: “When you break a mirror, you are sure to have years of bad luck.” This belief has absolutely no scientific basis. Of course, breaking a mirror is a rather unfortunate accident. You may cut yourself or cause injury to others. Therefore, we should be careful in handling objects that easily break.

One old, common practice was placing a metal spoon in a glass before pouring hot water into it. People believed that in so doing, one prevents the actual breaking of the glass. This belief has a clear and logical explanation. Metals absorb and conduct heat faster. When hot water is poured into a glass with a metal spoon in it, heat is absorbed by the spoon and is conducted away from the glass. This prevents the glass from breaking. This also explains why a metal ladle used in cooking easily gets hot and should therefore be provided with a rubberized or plastic-covered handle.

## Activity 1.8 Looking at Beliefs with an Analytical Mind

### Procedure

1. Column A gives a list of some common beliefs and practices. Without reading the statements in Column B, can you tell offhand which are superstitions? Which are scientifically based?

Column A	Column B
It is difficult to catch fish during a full moon.	Fish are easily attracted to light. During a full moon, the light reflected in the waters is scattered and covers a wide range. Naturally, the fish will also be scattered about, and a fisherman's lamp will not be bright enough to attract and keep a group of fish together.
A young girl who sings in front of a stove while cooking will likely marry a widower.	No scientific basis
A marriage solemnized during full moon will last forever.	No scientific basis
Don't look directly at the sun. The spirit of the sun will punish you.	The sun has no spirit, but it does emit high-energy beams (ultraviolet radiation) which can just as easily destroy sensitive eye parts. Constant exposure of the eyes to the sun (especially when it is unprotected) may eventually cause irreparable damage to the retina which can lead to blindness.
Losing a tooth in a dream is a sign that a relative has died or will die.	No scientific basis
A black cat crossing one's path brings bad luck.	This has no scientific basis. However, it is likely that you will not see the black cat crossing your path, especially at night. Thus, you may step on it, tumble, and hurt yourself. That is your bad luck.
A rabbit's foot is a lucky charm.	No scientific basis
At the end of the rainbow is a pot of gold.	No scientific basis
When you lose something, consult a fortune-teller. He can tell you where to find it.	No scientific basis
If you catch a small fish, throw it back or else the spirit of the water will punish you.	There are no spirits in the water which will punish you. Small fish should be allowed to grow and reproduce. If fish are caught before they are fully grown, there will be less fish to reproduce for the future.
Handling house lizards with bare hands causes warts ( <i>kulogo</i> ).	This has no scientific basis. Warts are caused by viruses.

A spoon that falls during a meal foretells the arrival of a female visitor; if a fork falls, you can expect a male visitor.	No scientific basis
---	---------------------

2. Check your initial answers with the explanations given in Column B.

How well did you score in this activity? If your score is at least 9, it shows that you possess an analytical and scientific mind.

## SUMMARY

This unit introduced you to what science and technology are all about. The work of some scientists, especially those of Filipino scientists, certainly gave you something to be proud of. Scientists think critically; they also have positive attitudes that are attributed to their success in their scientific endeavors.

You too can think and act like a scientist. You just have to practice the basic skills in observing, measuring, classifying, making inferences, and interpreting data. Mastery of these skills is important for coping with daily life. Acquisition of these skills is important for making decisions.

It has been shown that science and technology are complementary. They affect the development of society in general. They can help people regardless of their needs, abilities, or interests. However, each one has to be careful in selecting what technology to use for a specific situation and to learn how to dispose of them to prevent danger to life, property, and the environment.

## SELF-TEST

### I. Matching Type

Match the items in Column A with the description in Column B.

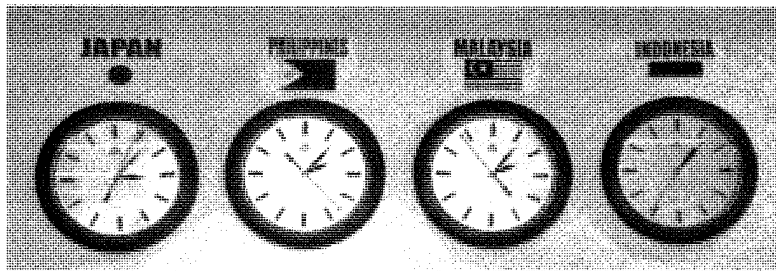
- | Column A           | Column B                           |
|--------------------|------------------------------------|
| 1. open-mindedness | a. belief with no scientific basis |
| 2. rash judgment   | b. hasty conclusions               |
| 3. curiosity       | c. bias                            |
| 4. prejudice       | d. respects ideas of others        |
| 5. superstition    | e. willingness to repeat trials    |
|                    | f. eagerness to know               |

## II. Open-ended or Constructed - Response Items

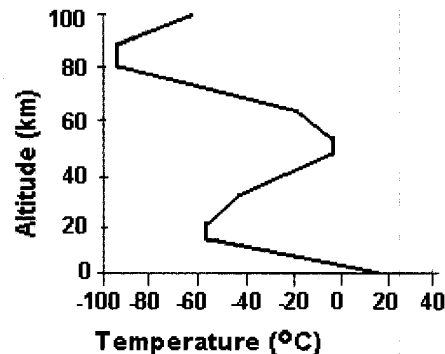
1. Inside the box is a list of waste materials. Group them in three ways. Give the basis for each grouping.

plastic containers, tires, dry paper, can with kerosene or thinner, softdrink bottles, food wastes, animal wastes, garden wastes, wet carton, metal scrap, bottle with muriatic acid, bottle used for storing pesticide

2. Give at least three similarities and three differences observed in the clocks shown. Give a possible reason for the differences.



3. Study the graph at the right.
  - A. Is the air temperature decreasing all the way from the ground to the upper atmosphere?
  - B. What is the air temperature near the ground? at a height of 20 km? at a height of 50 km?
  - C. At what height is the lowest air temperature recorded? The highest air temperature?
  - D. What do you think is the air temperature at about 120 km?



4. Mila will take a periodical test on Monday. She is worried that she might fail in the test because she has been absent for two days the past week. Her friend told her not to worry but to eat fish and peanuts the night before the test because these are brain foods. She followed the advice of her friend, slept and went to school the following day.
  - A. Do you think the advice of Mila's friend became helpful? Why or why not? (Clue: Nutrients are for all body parts.)
  - B. Do you think Mila passed the test? Why or why not?
  - C. If you were Mila, what would you have done to make sure that you pass the test?
5. Do science and technology benefit you? Cite an example.
6. Do science and technology affect you negatively? Cite an example.

## Unit II

# Scientific Method of Solving Problems



Scientists are like detectives. They use special methods to determine truths about things happening around. They gather facts and use these as clues, not answers, to scientific mysteries. They look at many relevant facts as they can and propose explanations for the events they observe. They conduct experiments to test their explanations. From the results of the experiments, scientists develop a theory—a powerful and time-tested concept that makes useful and dependable predictions about the natural world.

A theory is tested over and over again. When it survives the tests, it is presented to the scientific community. A theory may or may not be accepted outright. It may change after additional tests are made. And finally, if accepted as true by the scientific community, the theory becomes a law. But scientific laws are still scrutinized and may be changed as new data arise. In short, experimentation is the heart of science.

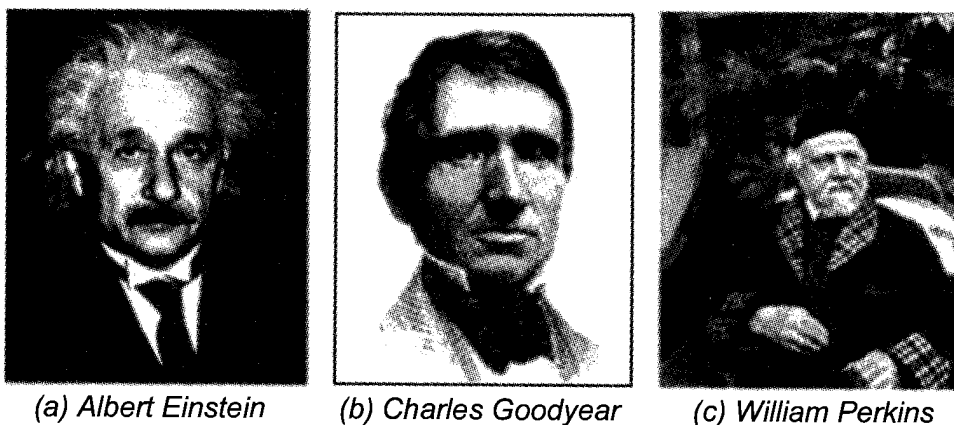
In this unit, you will be exposed to the different steps in conducting experiments or scientific investigations. Your findings may not become a law but you will experience the way scientists think and do their work.

## Lesson 2.1 Scientists Solve Problems in Different Ways

In Unit 1, you learned that Thomas Alva Edison discovered tungsten filament using trial and error method. Goodyear accidentally discovered rubber. In the same manner, Archimedes found the way to solve the King's problem (whether or not the crown was real gold or made of alloy) when he went into the tub almost filled to the brim with water and it overflowed.

Albert Einstein (1879-1955, German-American theoretical physicist) was able to arrive at the relationship between matter and energy using his intuition and intelligence. William Perkins (1838-1907, English chemist) discovered a synthetic dye by chance while looking for other things. This method of finding something else of value by chance is called serendipity. One case of serendipity occurred in the research laboratory of a company that produces sticky tape. In the 1970s, some researchers found a new bonding agent but decided that it was worthless since it could not stick a paper tightly to a surface. This failure was later on converted into a successful product, Post-it notepads.

Most scientists however, follow the experimental method of solving problems. You will learn more of this in Lesson 2.2.



*Figure 2.1 Some famous scientists. What are their other contributions to science and technology besides those already mentioned?*

- Q2.1 Explain the phrase. "There are as many methods as there are people seeking solutions to a certain problem."
- Q2.2 Cite one advantage of the trial and error method in solving a problem. Give one disadvantage.
- Q2.3 Do you think anybody can discover something by chance? Why or why not?
- Q2.4 Among the ways of solving a problem, which one gives consistent results? Explain your answer briefly.

Scientists use different methods in solving problems but they follow certain steps. They ask questions about the phenomenon or situation observed. They carefully observe and look for regularities in their observations. Sometimes they discover something accidentally or by chance but they have a “ready mind” because they can immediately see what is of value from what is not. They are able to synthesize observations and make good inferences. Only investigators with trained scientific minds could chance upon such findings.

Is there such a thing as the “best” way to solve a problem? The answer to this question may vary with the situation. The important thing is for people to observe keenly and ask the right question at the right time. You must have noticed that many people accept as truth what they see, hear, or read. They make conclusions solely based on that information and without verifying the source of that information. More often than not, this attitude gives rise to misunderstanding and problems.

Asking the right questions at the right time is a sign of curiosity, objectivity, and a desire to learn more. Asking the right questions could reduce bias, anxiety, or even panic. The rule to follow is: If you are not sure about anything, ask.

### **Activity 2.1 Asking Questions**

#### **Procedure**

1. Form a group with about five members each. A smaller group will allow members to participate more actively in the discussion.
2. Read the situations below. Choose one for your group to brainstorm on and answer questions a to d.
  - a. What questions come to your mind when you read the situation?
  - b. How will you find out answers to these questions?
  - c. Why did you choose that method of finding out the answer to your questions?
  - d. Could these problems be prevented? How?

**Situation 1:** Yesterday was your town fiesta. You visited several houses. You were served lots of food. That night you had stomach ache and started vomiting.

**Situation 2:** You have seen the commercial on shampoo endorsed by your favorite actress. Her hair looks beautiful. You tried the shampoo yourself. After one week, you observed you have lots of falling hair.

**Situation 3:** There is a cholera epidemic in one part of your town.

**Situation 4:** The fish catch in the lake is dwindling.

3. Listen to the presentation of the other groups. Compare your method with their methods. Are there similarities in the methods used? What are different?
4. Among the methods presented, which is the best way to find out the cause of a problem? Why is it the best way than the other methods presented?

Questions about an object or situation can be answered by any of the following methods: observing the object or situation, recalling past knowledge and inferring what could have caused the problem, reading books or journals, interviewing people or experts on the subject matter, and/or conducting a scientific investigation. Some questions or problems may have several answers. Other questions are opinion based, that is, there are no right or wrong answers. But, when giving an opinion, it is important that you have a sound basis for it.

#### **Home Activity**

Write a short essay on one of your most unforgettable experiences or problems. Narrate how you arrived at your answer. Do you think that method was the best? Explain your answer.

## **Lesson 2.2 The Scientific Method of Investigation**

As mentioned earlier, most scientists perform experiments to work out solutions to problems. Doing experiments or conducting scientific investigations enabled them to see cause-effect relationships. The experimental method involves several steps. Galileo Galilei (1564-1642, Italian astronomer and physicist) used this method when he discovered the principle of the pendulum. Joseph Priestly (1733-1804, English clergyman and chemist) identified the gas, carbon dioxide, using the same method. Even Francesco Redi (1636-1697, Italian physician) followed the experimental method when he proved that living things come from the same species. Read about these discoveries at your own time.

What are the basic steps of the experimental method of investigation? How do we go about doing these steps?



### **1. Identify or define the problem.**

What problem or issue do you want to work on? Is the problem clear and specific? Is the solution to this problem attainable? For example, Dario's problem (in Unit 1), was finding out how he could make an herbal preparation that would stay long in contact with the wound.

Q2.5 Was Dario's problem clear and specific? Was a possible solution in sight? Why or why not?

If you are not sure what you would like to do, consult a local professional or read more about the problem.

### **2. Gather enough information and study them.**

What has been achieved so far in relation to the problem? Are the given facts relevant and measurable? Read Dario's study.

Q2.6 What relevant information did Dario use in designing his experiment?

Q2.7 What valuable information did Dario get from his teacher?

Get only relevant information about the problem. People's ideas and arguments may be considered. When organized, the information may reveal some patterns, regularities, or trends that will establish relationships among given facts. Patterns and trends help in making hypotheses.

### **3. Formulate the hypothesis.**

Think about what might happen in response to certain inputs or assumptions. A hypothesis is an educated guess and must be based on information from past researches or literature studies. Dario's hypotheses were:

- a. mixing the oily herbal medicine with wax will allow longer contact between the medicine and the wound;
- b. using beeswax instead of candle wax will result to a softer ointment that will not harden when cooled off; and
- c. using the beeswax-oil-herbal preparation will allow longer contact with the wound and promote faster healing.

Essentially, the hypothesis provides the ground or justification for conducting specific studies and guides the investigator in the course of his or her study. Before a hypothesis can be accepted as a fact, it has to be proven first through experimentation and the findings have to be supported by more than one testing to erase any doubts of a chance success. When the subsequent testing fails to support the given

hypothesis, such hypothesis should be considered null and void (untrue) and therefore discredited.

#### 4. Test the hypothesis.

An experiment designed to test a specific hypothesis involves only those factors whose effects are to be studied. These factors are known as **variables**. Two types of variables are considered: those that can be controlled and those that can be changed or manipulated. The variable that is changed (or that changes) is called the **independent variable** while the variable that responds to the change is called the **dependent variable**. Remember the rule: Vary only one variable or factor at a time while keeping all other factors in the experiment unchanged or constant.

In an experiment, a **control setup** is used as reference or standard against which the results of the experimental setups will be compared. For example, one of Dario's hypotheses was "if the oily herbal medicine will be mixed with wax there will be longer contact between the medicine and the wound." His control setup was the herbal medicine without wax and the experimental setups were the different combinations of wax and herbal medicine.

Note that testing or experimenting is done under controlled conditions (preferably indoors where temperature can be regulated at will), although this is not possible when conducting field studies. Wherever you are doing your investigation, observations should be done closely to see if any relationship exists between and among sets of collected data. Establishing relationships is essential in the experimental method.

Q2.8 What were the variables in Dario's experiment?

Q2.9 Which variable was made constant?

Q2.10 Which variable was changed?

#### 5. Make a conclusion.

All collected data are clearly analyzed and correctly interpreted. This analysis helps any investigator decide whether to accept or reject his or her hypothesis. From this, a conclusion or a general statement can be made about the study.

Q2.11 Which of Dario's hypotheses were accepted?

Q2.12 Why were those hypotheses accepted?

Q2.13 In your own words, state Dario's conclusion.

#### 6. Verify the conclusion.

To make sure that the findings are conclusive, repeat the experiment using the same procedure and conditions. The same person or another

person may do this. If the results are almost the same, the conclusion is deemed valid.

What are the important parts of a science investigation? Do Activity 2.2.

### **Activity 2.2 Identifying the Parts of an Investigation**

#### **Procedure**

1. Read the following abstract of a research.

#### A Research Abstract

The Nobel Prize winning scientist Karl von Frisch studied the behavior of honeybees. He thought that bees could distinguish one kind of flower from another. He suspected that the bees could distinguish flowers by color.

To determine if this was true, he designed a set of simple experiments. He first trained bees to come to a source of honey located on a piece of blue card. The bees made many trips between their hives and the source of food on the blue card.

The blue card was then removed and replaced with a clean blue card and a clean red card which did not contain honey. The bees returned to the blue card and avoided the red card. The bees were able to distinguish the blue card from the red card.

After von Frisch published his results, other scientists designed similar experiments. Their findings supported von Frisch's hypothesis.

2. From the research abstract,
  - a. identify the following:
    - problem to be solved
    - hypothesis
    - basis for the hypothesis (the rationale)
  - b. describe the following:
    - variables in the study
    - dependent variable
    - independent variable
    - control setup
    - experimental setup
  - c. state the following:
    - findings of the study
    - conclusion
    - recommendation/s

Are you now ready to do your own scientific investigation? The next activity will guide you.

## Lesson 2.3 Conducting a Guided Investigation

A study may start with an observation or a situation. For example, you observe that the flagpole casts a shadow. Some hours of the day, the shadow is long; other times, it is short. What questions come to your mind? What questions can be investigated, given your educational background and limited resources?

Did you ask a question about what might affect the length of the shadow? Is your question similar to the following: "Is the length of the shadow affected by the position of the sun in the sky?" Or, "Does the position of the sun in the sky affect the length of the shadow?" Either problem is correctly stated. Either problem is specific and measurable.

The seven short activities that follow will guide you in the process of investigation.

### Activity 2.3 Stating a Problem for Investigation

#### Materials

any object or situation of interest

#### Procedure

1. Study the object or situation assigned to your group or one you chose to study.
2. Individually, write three questions about the object or situation in 5 minutes.
3. Discuss your questions within the group. Try to answer each question.
  - a. What questions were easy to answer? Why were you able to answer them easily?
  - b. Why can you not answer the other questions easily?
  - c. Which question can you investigate, given limited time, resources, and science background?
4. As a group, state the specific problem that you want to investigate.

In general, questions that require you to recall observations or repeat given information are considered low-level questions. These questions do not require much thinking. High-level questions, on the other hand, require you to think about why and how things happen. Furthermore, you need to think of possible answers to the question (formulate hypotheses), test one hypothesis at a time to determine cause-effect relationship, and make conclusions based on the data gathered.

Go back to the problem about shadows. Do you think there is a relationship between the position of the sun in the sky and the length of an object's shadow? Then state your hypothesis using this structure: "If the length of an object's shadow changes at different times of the day, then the position of the sun affects the length of the shadow." Another way of stating the hypothesis is "An object's shadow is shorter during noontime than early in the morning." Still another statement may look like this: "The position of the sun in the sky affects the length of an object's shadow."

Remember, you can have many hypotheses for one observation. You can also state your hypothesis in different ways, for as long as the factors involved in the study are included in the statement.

#### **Activity 2.4 Formulating a Hypothesis**

1. Study the problem identified by your group in Activity 2.3.
2. Individually, write a hypothesis for the problem using the "If...then" structure or other ways of stating a hypothesis shown in the example above.
  - a. Does your hypothesis state the relationship between the factors involved in the study?
  - b. Does the hypothesis give a tentative answer to the problem or question?
3. As a group, decide on one hypothesis that will give you an idea what might happen in response to certain inputs that you will do in the next activity. Show your hypothesis to the teacher before doing Activity 2.5.

Now, you are ready to design a procedure to test your hypothesis. Again, go back to the hypothesis about shadows. To test your hypothesis, you have to actually observe an object's shadow at different times of the day and measure its length or height.

Think of what might affect the shadow—the position of the sun at different hours of the day, the brightness of the surrounding, the position of the flagpole in relation to the sun, the height of the flagpole, and the time when the observation and measurement are made. Also, think about

how the length of an object's shadow changes with the position of the sun. The position of the sun (the variable that changes) is the independent variable while the length of the shadow (the variable that responds to the change) is the dependent variable.

What variables should be kept the same in order to have a fair test? Apart from the independent variable, all the other variables should be kept the same. In this way, you will be able to say that any change in an object's shadow must have been caused by the change in the position of the sun. Remember that the success of any scientific investigation depends largely on the scientist's ability to control variables.

Also, remember that the independent variable must be given values. For example, the position of the sun can be observed at different hours of the day: 9 a.m., 12 noon, and 3 p.m. The dependent variable or the length of an object's shadow must be measured using a standard instrument (e.g., a meter stick).

### **Activity 2.5 Designing a Procedure to Test Your Hypothesis**

1. From your hypothesis in Activity 2.4, identify all the variables in the study.
2. Identify the following:
  - a. independent variable;
  - b. dependent variable; and
  - c. variables that you need to control.
3. Give values for your independent variable.
4. Tell what instrument you will use to measure the dependent variable.
5. Write down the whole procedure for the experiment.

Assuming that you have gathered the data, how will you show what happened in your experiment? Results of data collection are best recorded in table form. For the experiment on shadow, the recorded data may look as follows:

<b>Time of Observation</b>	<b>Length of the Flagpole's Shadow (m)</b>
9:00 a.m.	9.2
10:30 a.m.	7.3
12:00 noon	5.1
1:30 p.m.	7.4
3:00 p.m.	9.2

From the data table, can you see a pattern from the set of data? Let us graph the given data (Figure 2.2).

In Figure 2.3 notice that the length of the flagpole's shadow tends to be longer in the morning and in the afternoon when the sunrays seem slanted as they reach the ground. The shadow gets shorter at noon when the sunrays seem to reach the ground almost perpendicularly.

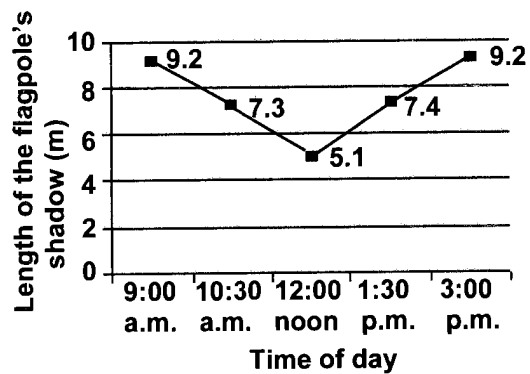


Figure 2.2 Relationship of the length of flagpole's shadow with the position of the sun during certain hours

Observe how the shadows in the morning and in the afternoon appear in the opposite direction. These results mean that the position of the sun affects not only the length of the flagpole's shadow but also its direction or position. These observations can then be explained using Earth's rotation on its axis.

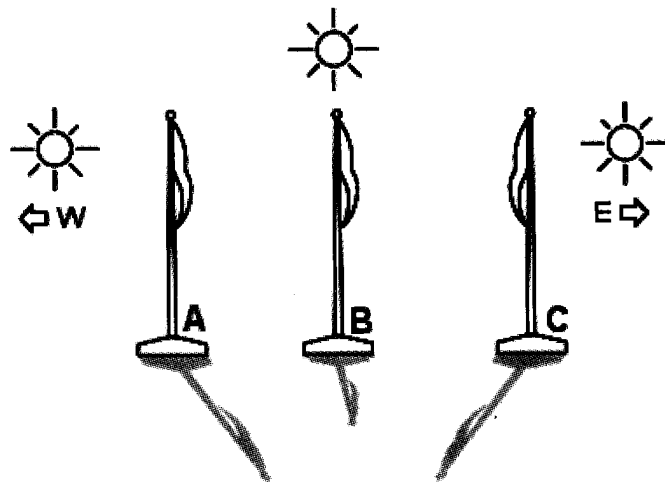


Figure 2.3 Length and direction of the flagpole's shadow at different times of the day. Give a possible reason for each observation (A, B, and C).

If you repeat the activity on shadows another day, you may get slightly different results but the same pattern can be observed. Another difficulty that may arise is when the sun may be slightly covered by clouds and the flagpole's shadow may not be clearly seen.

Q2.14 What do you think would be the result if the experiment were done at another time or season of the year? Why do you say so?

Complete your investigation by doing the next activity.

### **Activity 2.6 Collecting, Organizing, and Interpreting Data**

#### **Procedure**

1. Follow the procedure described in your design (Activity 2.5).
2. Record your data in a table. Measure up to the tenth value.
3. Graph your data. Make sure you put the independent variable and the dependent variable in its right place in the graph.
4. Study the graph.
  - a. Is there a pattern in your results? Describe the pattern.
  - b. What do you think the results tell you?
  - c. Are there any surprises in your results? What do you think the results tell you?
  - d. What do you know now that you didn't know before you started the experiment?
  - e. What have you learned from your investigation?
5. List down problems you encountered while conducting your experiment.
6. Make recommendations so that others who may want to do a similar experiment will not meet the same problems.

To get meaning out of the data you collected, look back at your original prediction or hypothesis to see whether or not the evidence supports it. Then try to explain the relationship between the independent variable (what was changed) and dependent variables (what responded to the change and were measured). You might even have to go back to the activity to make further observations when trying to explain results.

Was your test fair? The shadow experiment was a fair test because all variables, except one, were controlled. Also, data collection was done at specific times. Furthermore, the same measuring instrument was used to determine the length of the shadow.

Q2.15 Read the description of tests done by two children. Which test is fair? Give a reason for your choice.



**Test 1:** Ana wanted to find out how much water plants need to grow and develop normally. She put the same kind and amount of soil in six pots of the same size. She planted the same kind of seedlings into each pot. The seedlings were of equal age and heights at the time they were planted. She placed all pots in a sunny place in their backyard. Then she watered each pot everyday with different amounts of water.

**Test 2:** Mario wanted to classify water samples from different sources as hard or soft. He chose bottles of the same sizes and placed equal amounts of water in each bottle. Then he put the same size of soap but of different brand names into each bottle. He shook the bottle the same number of times and measured the height of the bubbles produced.

As you have seen, variables are central to science investigations. If you can identify the variables in your study, this will help you design the procedure of your investigations as well as interpret the results later.

## Lesson 2.4 Decision-Making in Scientific Investigations

Conducting scientific investigation requires many decisions to be made. Review these steps using the following problem.

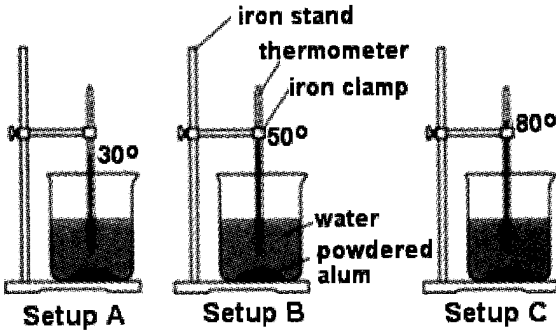
Problem: Does alum dissolve faster in hot water?

Hypothesis: Alum will dissolve faster in hot water.

Without looking at Column 3 try to answer the questions in Column 2.

**Table 2.1 Decision-Making Process When Conducting a Scientific Investigation**

Aspects of Investigation	Questions	Decisions
Deciding on key variables	What will you change?	Water temperature
	What will you measure?	The time it takes for alum to dissolve in water samples having different temperatures
Asking questions	What will you find out?	If the dissolution of alum is affected by the temperature of water
Hypothesizing	What do you think will happen?	Alum dissolves faster at a higher temperature.
	Why?	As water temperature is increased, it can be inferred that both water and alum molecules

		will move faster and collide with each other more. Thus, alum will dissolve faster with increasing water temperature.																				
Designing	<p>What values will you give the independent variable (water temperature)?</p> <p>What equipment will you use to measure the speed at which dissolution of alum occurs?</p> <p>How will you make it fair?</p>	<p>Water temperature will be at room temperature (about 30 °C, 50 °C, and 80 °C).</p> <p>A watch with a second hand or timer</p> <p>The following factors should be kept the same: kind and size of container, amount of water, and amount of powdered alum.</p>  <p>Setup A      Setup B      Setup C</p>																				
Recording	How will you show the results?	<p>I will record all data in a table. Then, I will graph the tabulated data.</p> <table border="1"> <thead> <tr> <th>Set-up</th> <th>Water Temp. (°C)</th> <th>Amount of Water (mL)</th> <th>Amount of Alum (g)</th> <th>Time Dissolved (min)</th> </tr> </thead> <tbody> <tr> <td>A</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>B</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>C</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>	Set-up	Water Temp. (°C)	Amount of Water (mL)	Amount of Alum (g)	Time Dissolved (min)	A					B					C				
Set-up	Water Temp. (°C)	Amount of Water (mL)	Amount of Alum (g)	Time Dissolved (min)																		
A																						
B																						
C																						
Finding patterns in results	Can you see a pattern?	The speed of alum dissolution became faster as water temperature increased.																				
Making sense of patterns in results	What do the test results mean?	I think I was right. Alum dissolved faster as water temperature increased.																				
Evaluating the reliability of the test	How good was the test?	Repetition of the activity gave a consistent result, so the test must be reliable.																				

Q2.16 As a group, test another hypothesis: “Small pieces of alum dissolve faster than big ones”. Use as guide the questions in Column 2 of table 2.1. Be ready to discuss the results of your decision-making activity in class.

## Lesson 2.5 Conducting an Investigation Without Doing Laboratory Work

So far, the examples given to you are investigations that require handling equipment or materials in a laboratory. In Astronomy, Geology, or Meteorology, the luxury of performing experiments is limited. This is because of the need to work in large scale “laboratories” like the Earth and space. Moreover, these sciences usually deal with great magnitudes of time—thousands to billions of years—as those used in geologic time scale. Nevertheless, the experimental method is still applicable. Scientists use observation skills to arrive at a logical conclusion, which later can become a theory, and then a law.

How are these observations done? For example, how did Aristotle (384-322 B.C., Greek philosopher) arrive at a conclusion that the Earth is round? He observed lunar eclipses!

During one lunar eclipse, Aristotle saw that the Earth cast a shadow onto the surface of the moon. He hypothesized that the Earth must be round because its shadow looked like an arc of a circle. He predicted that any and all future lunar eclipses would show the Earth’s shadow to be curved regardless of its orientation. He had the same observation every time a lunar eclipse occurred.

Aristotle’s prediction has yet to be proven wrong. His reasoning formed the basis for all scientific inquiry today. He was not the first to argue that the Earth was round but he was the first to offer proof using the lunar eclipse method. He used scientific inquiry in formulating his theory about the Earth. He followed the following steps. He first made an observation. Then he formulated a hypothesis to explain his observation. Lastly, he tested his hypothesis by making a prediction that could be confirmed by further observations.

### Home Activity

You know what a rainbow is. But have you seen enough rainbows that you can make a general statement about when rainbows appear? If not, do more observations the next time you see rainbows.

## Lesson 2.6 How Good Is Your Science Investigation Project?

How do you know that your science investigation was done properly and reported correctly? To grade your project objectively, rubrics or scoring key is used. Rubrics are matrices that define what are expected in a learning situation. Rubrics describe the level of performance for each aspect of the investigation and the criteria for each level. These are the criteria that your teacher will use in rating your outputs. These are also similar to the criteria used by judges when rating your science projects in a science fair.

It is good to know the criteria for scoring your outputs so that you will be guided on the important aspects of the investigation or research.

**Table 2.2 Sample Rubrics for a Scientific Investigation Project**

Parts of the Project	Excellent (40 points)	Satisfactory (30 points)	Fair (20 points)	Needs Improvement (10 points)
Problem	specific	general	not clear	not given
Hypothesis	association between the problem and the predicted result is direct (shows if...then relationship)	problem is stated but predicted result is not	hypothesis not stated directly	no hypothesis
Design	thorough and appropriate to the problem  list of materials complete  control and experimental setups are identified  dependent and independent variables clear; with logical procedure and can be replicated	lacks minor details  list of materials complete  control and experimental setups are identified  dependent variable identified but not the independent variable; procedure is not described in detail	missing major design components  list of materials incomplete  only experimental setup given; no control setup  both dependent and independent variables are not identified	not applicable to the problem   the design is wrong and does not help answer the problem  procedure difficult to follow

Data collection and analysis	all significant data collected, measured and recorded  gives accurate tables and charts  analysis in agreement with the data collected  results explained clearly	data collection complete  tables presented but no charts  analysis of data inadequate but does not affect the accuracy  results are interlinked	inadequate data collected  raw data presented but no tables nor graphs  analysis of data is inadequate and affect the accuracy  some explanations are innacurate	data collected not useful  no tables nor graphs  analysis is wrong  explanation is wrong
Conclusion	acceptance or rejection of hypothesis supported with evidence	relates to the hypothesis but conclusion is just implied	conclusion not very clear; too general	conclusion does not answer the problem

Rubrics can also be used to evaluate answers to open-ended questions, essays, reaction papers, and many others. There are different rubrics or scoring criteria for different outputs.

The next activity gives you experience on rating scientific investigation of others. Then you will be able to use the same rubrics for evaluating your own output.

### Activity 2.7 Critiquing a Science Investigation Project

#### Procedure

1. Read the report below.
2. Use the rubric and give each aspect of the report a score.
3. Total your score and give a final rating.

#### Effect of Phosphate-Containing Detergents on Growth of Algae

##### Overview

The purpose of this project is to determine whether or not phosphates affect the growth of algae as might be found in lakes and streams. Phosphates are found in plant fertilizers, animal wastes, and

detergents. These could reach streams and lakes via runoff from homes and drainage pipes. If these affect algal growth, such runoff needs to be controlled.

### **Hypothesis**

Phosphates (such as those coming from detergents) contribute to algal growth. More algae will grow with higher amounts of phosphates in water.

### **Experimental Design**

- Independent variable: amount of detergent
- Dependent variable: growth of algae
- Variables controlled: amount of water used, amount of algae, length and time of observation, a light source or direct sunlight
- Control setup: container with distilled water and algae
- Experimental setups: three containers with different amounts of a particular brand of detergent but with equal amounts of distilled water and algae

### **Materials**

3 containers with cover (small plastic bottles will do)	distilled water
detergent with phosphates	graduated cylinder
sample algae from a lake or stream	light source or direct sunlight
open-mouthed container	
stirrer	

### **Procedure**

#### Preliminary Activities

1. Sample algae from the lake was collected and placed in a small open-mouthed container. It was gently stirred so as to break up major clumps. This is the starter culture.
2. Detergent containing phosphate solution was prepared by putting 2 grams of detergent in 20 mL water.

#### Activity Proper

1. Container 1 was labeled "distilled water." It was filled with distilled water, about three-fourths full. This is the control setup.
2. Container 2 was labeled "10% phosphate solution". It was prepared by mixing one part of phosphate solution in nine parts distilled water.
3. Container 3 was labeled "20% phosphate solution". It was prepared by mixing two parts phosphate solution in eight parts distilled water.
4. Two teaspoons of algae culture were added into each container. The bottles were shaken gently to mix the contents.

5. The bottles were covered tightly and placed side by side on a window sill where they can remain unmoved for the duration of the experiment.
6. Observation of the containers was done at the beginning of the experiment and everyday thereafter for eight days.

### Results

Duration of the Experiment	Control Setup (distilled water + algae)	Experimental Setup 1 (10% phosphate solution + algae)	Experimental Setup 2 (20% phosphate solution + algae)
Day 1	light green	light green	light green
Day 2	slightly darker green than Day 1	slightly darker green than Day 1	slightly darker green than Day 1
Day 3	darker green than Day 2	darker green than Day 2	darker green than Day 2
Day 4	darker green than Day 3	darker green than Day 3	darker green than Day 3
Day 5	algae spread on surface	more algae spread on the surface	dense algae cover
Day 6	slightly cloudy	more cloudy than control setup	more cloudy than experimental setup 1
Day 7	dark green	darker green; thick algae cover	darkest green; thicker algae cover
Day 8	thin dark green cover	thicker algae cover	thickest algae cover; liquid smells like decaying matter

### Conclusions

1. There were more algal growth in the 10% and the 20% phosphate solutions than in distilled water.

2. Algal growth in the 20% phosphate solution was thicker on the seventh day than in the 10% solution.
3. Excessive phosphates will affect the lake environment; more algae decayed in the 20% phosphate solution than in the 10% solution and distilled water.

#### **Recommendations**

1. A study should be made on the effect of higher levels of phosphate on algal growth.
2. A study should be made on the synergistic effect of nitrates and phosphates on algal growth since both nitrates and phosphates are found in runoff.
3. A study should be made on the effect of detergents on fish or other aquatic life.

Q2.17 What is the level of performance you gave to the project described above? Why did you give it that rating?

Q2.18 Recall the investigation you did in Activities 2.3 to 2.6. What rating will you give that output? Why did you give it that score?

You might have asked: Do scientists almost always follow the steps in the experimental method in the order they were described in the previous lessons?

In reality, the answer is NO. They may not always follow all the steps in the experimental method as they have been described. The steps may not even be followed in the same order. While performing an experiment, a scientist may observe something totally unexpected, something that might require a change in his or her hypothesis. In this situation, the problem came after a hypothesis. Or a scientist might not even start out with a particular problem because, as he or she observes unexpected results, he or she might look at the situation in a new way or consider a new problem. In this case, the problem followed an experiment.

Still, another reason why scientists deviate from some rules when conducting science investigations is when it is not possible to control one variable at a time. For example: When studying why the path of a typhoon changed, it is difficult to isolate the atmospheric temperature and pressure from the moisture content of air. The factors that affect typhoons have to be studied all together and according to how these factors interact with each other. Similarly, a landslide occurs because of the interactions of the following: amount and duration of rainfall, topography of the place, and kind of soil cover.



However, for beginners, it is always better to follow the basic steps of the experimental method when conducting science investigations.

## **Lesson 2.7 Are You Ready to Do Your Own Science Investigation?**

The basic steps in conducting science investigations are: identifying the problem; gathering information about the problem; formulating a hypothesis; testing the hypothesis; seeking out patterns and regularities; drawing a conclusion; verifying the conclusion; and making generalized statements or predictions.

In Unit 1, you were given some titles of student projects that won awards in the International Science and Engineering Fair (ISEF). The list below gives topics or problems you might want to investigate for your science class.

1. Your father is an ice cream vendor. Which local materials will keep the ice from melting fast?
2. Soil in your garden is sandy. How can its water-holding capacity be improved?
3. How can you prevent the growth of molds on bread?
4. Will plants grow in any other media aside from soil?
5. Which color absorbs more heat—black or red?

What do you notice about the above-mentioned sample problems listed and the ones students submit for science fairs? Yes, they are real - life problems!

Remember: Science is not just about doing laboratory work. Science is helping us make sense of the materials, events, and phenomena around us through the use of our senses.

### **SUMMARY**

There are different ways of solving problems. Some scientists use their intuition; others use trial and error. Still, others discover something by chance. Most use the experimental method in finding truths about nature and cause-effect relationships.

The experimental method requires an investigator to ask a question and to give it a tentative answer (hypothesis). Scientists then design and set up an experiment to test the hypothesis. They gather pertinent data for a certain period of time. They organize and analyze the data gathered to answer the question or problem being investigated.

Observation, hypothesis formulation, and testing (by controlling variables) compose the cornerstone of the experimental method, often referred to as the scientific way of solving problems. This method enables anyone to arrive at a conclusion that is free from personal bias. Moreover, it allows one to look at everyday situations with an analytical mind.

Investigating is just one activity in science, but a very important one. It requires the use of all the basic process skills you learned in Unit 1. These are important skills that will enable you to appreciate the content and activities in the succeeding units.

## **SELF-TEST**

Answer the following.

1. You find snake eggs underneath untouched stone or wood. Give at least two hypotheses for this observation.
2. Mina carried out an experiment using setups A, B, and C. In container A she had water with ice and a thermometer. In container B, she had tap water and a thermometer. In container C, she had warm water and a thermometer. In each of the three containers, she added sugar cubes. What do you think is Mina trying to find out?
3. Rica could not unscrew the metal cap of a bottle of syrup. She hypothesized that syrup must have caramelized inside the grooves of the metal cap. Her brother suggested to pour hot water over the bottle cover. Her sister said to light a candle and heat the bottle cap over it. Do you think the methods suggested will help Rica open the bottle? Why or why not?
4. Suppose you received an orchid plant as a birthday present three years ago. Until now, the plant has not bloomed. You want to find out why.
  - A. What factors should you take into account in finding out how to make the orchid bloom?
  - B. What will your experimental plan be?
5. Jose wanted to find out how long it takes for parachutes made of different materials to fall on the ground. He made parachutes of the same sizes and dropped them from different heights.
  - A. Is this test fair? Why or why not?
  - B. If it is not a fair test, how can you make it fair?
6. You have been assigned to provide music for the class party. The program is about to begin in a few minutes. But the karaoke you brought does not work. How will you apply the experimental method to determine the cause of the problem?

## Unit III

### Investigating Matter



Our planet, Earth, is a storehouse of materials. You will find rocks and minerals from its solid part called the lithosphere. You will find water in seas, oceans, lakes, and rivers. Water covers about three-fourths of the lithosphere which is called the hydrosphere. You will find gases in air which make up the atmosphere. There are many more. Try to think of other materials in your immediate environment. With thousands of materials around you, how can you distinguish one material from another?

You can investigate the properties of the materials you are interested in. Look for patterns and trends in your observations and then use these to devise some methods of classification. Any method can be a great help in organizing, analyzing, and interpreting various data or information.

A very common method of classification is based on physical properties, like state, shape, color, and texture. Another classification can be based on chemical behavior (how one material interacts with another material). A third method could be based on uses. You can devise your own. There is really no "correct way" of classifying matter. However, a system of classification acceptable to many science practitioners exists.

## Lesson 3.1 Classification of Matter

Anything that has mass and volume is matter. The trees, rocks and soil, and the insects in your garden are all matter. Likewise, the water you drink, the gasoline and motor oil in the vehicle you ride in, and the air that you breathe are all matter. Even the bacteria and viruses that you cannot see with your unaided eyes are considered matter. One way that scientists use to classify matter is to group them into living and nonliving.

Generally, we classify matter as living if it breathes, moves, eats, grows, responds to things and situations around it, and has the ability to reproduce its own kind. Without these characteristics a piece of matter is considered nonliving. However, some characteristics of living things are used to describe nonliving things. Air, a nonliving thing, is said to “move” when strong gusts of it hit your face. Some stones, stalactites, and stalagmites in caves are said to “grow” as more of them become deposited on their surface so that these objects increase in size. In what way then are living things different from nonliving things?

For instance, you need food in order to survive. For your body to be able to use this food, the food must first be broken down into simpler substances that can be absorbed by your tissues and cells. Some of these simpler substances are then converted into nutrients for use in the repair of your worn-out tissues. Some are converted to energy essential for your everyday activities such as breathing, digesting, absorbing, converting food into body parts, or eliminating what is not needed or is poisonous to the body. This series of processes is called **metabolism**.

Only living things metabolize. The result of these metabolic processes is that the living thing actually grows. Growth results in the conversion of substances from the environment, like air, water, and food, into a part of the organism's body. Such a growth can only come from within. Most plants grow almost unceasingly throughout their lives. But animals, including man, have a definite growth period, which stops when they reach adulthood. At this point they would have reached a maximum height.

Another characteristic that differentiates living things from nonliving things is their ability to reproduce their own kind. Plants can reproduce themselves by a variety of methods. New plants can grow from spores, seeds, stem cuttings, suckers, runners, and other human-devised techniques, such as grafting, budding, and marcotting. Animals likewise reproduce their own kind. Frogs reproduce frogs and cats reproduce cats. You have the characteristics of either your mother or your father or both because you came from both of them.

## Kinds of Mixtures

Water is tasteless and colorless. Sugar is sweet and often used in the form of small crystals. Its color, depending on its stage of purification, may be brown, "washed" or cream, and white. When you add some white sugar to water, the water remains colorless but becomes sweet. The resulting water is no longer the original tasteless water but has become a combination of two materials, sugar and water. Where did the sugar go? Why can't you see it anymore? It has mixed thoroughly with water. It is still there but its particles are no longer visible to the unaided eye. Water and sugar are called substances. Together they form a kind of matter called **mixture**. The components of a mixture are called **solute** and **solvent**. In the sugar-water mixture, sugar is the solute and water is the solvent. Normally, the component with the greater amount is considered the solvent. The solute has lesser amount and is the one that dissolves in the solvent. The composition of mixtures varies because the amounts of its components also vary.

A mixture may be homogeneous and heterogeneous. **Homogeneous mixtures** are uniform throughout. The composition is the same in all directions in the mixture. The solute and solvent particles that you observe in one direction are the same as those you observe in all others. The mixture of sugar in water is homogeneous. **Heterogeneous mixtures** are not uniform. The composition is not the same in all directions in the mixture.

Try to expand the definition of mixtures by observing other mixtures in Activity 3.1.

### Activity 3.1 Mixtures

#### Materials

salt	bottles	evaporated milk
water	stirring rod	penlight
sand	rubbing alcohol	cooking oil

#### Procedure

1. Half-fill 5 bottles with water. Label the bottles A to E.
2. Add a teaspoon of salt to Bottle A. Stir the water.
3. Add a teaspoon of rubbing alcohol to Bottle B. Stir the water.
4. Add a teaspoon of cooking oil to Bottle C.

5. Add a teaspoon of sand to Bottle D. Do not put anything to Bottle E.
  - a. What does Bottle E represent?
6. Let the bottles stand undisturbed for about 10 minutes and observe again.
7. Focus a lighted penlight on the mixture in each bottle. Look at the mixture at right angle to the path of light.
  - b. What was formed in each bottle? Did you get the same results?
  - c. Identify the solute and the solvent in each mixture.
  - d. Which mixture/s is/are homogeneous? Heterogeneous?
  - e. What did you observe after a ray of light was focused on the mixtures?
  - f. Based on your results, distinguish the three kinds of mixtures.

Unlike sugar, sand does not disappear in water. It is not evenly distributed within the solvent. Much of it readily settled at the bottom of the container. Some were suspended in water but later settled at the bottom just like the rest of the particles. The mixture of soil in water is heterogeneous.

**Mixtures** may be classified into solutions, colloids, and suspensions according to their particle size. Solutions and colloids are homogeneous mixtures while suspensions or coarse dispersions are heterogeneous mixtures. The particles of solutions and colloids are smaller than those of suspensions. Solutions have the smallest particles.

A mixture of water and alcohol is homogeneous. The particles of water and alcohol are spread uniformly throughout the solution. Liquid solutions are transparent. You can see through them. The mixture remains stable and does not separate after standing for any period of time. The particles are so small that they cannot be seen by the unaided eye. **Solutions** can pass through a filter paper because their particles are smaller than the pores of the filter paper. It is also for this reason that light can pass through a solution. The particles cannot scatter light focused on them. Some solutions may be colored but they will still be transparent.

**Colloids** are mixtures with particle size that are larger than those of solutions but smaller than those of suspensions. The particles cannot be seen by the unaided eye but may be seen through a high-powered microscope. The particles of colloids are small enough to pass through a filter paper but large enough to prevent light from passing through and so scatters light. Fog and milk are examples of colloids. You have seen how

fog interacts with the light from a car's headlight. Colloids look homogeneous to the naked eye but often appear murky or opaque.

**Suspensions** are mixtures with particle sizes that are greater than solutions and colloids. That is the reason why they are visible to the naked eye while solutions and colloids are not. The particles cannot pass through a filter paper. Suspensions are also murky and opaque and they do not transmit light.

## Separating the Components of Mixtures

Can components of mixtures be separated from one another? Are components chemically combined?

### Activity 3.2 Separating the Components of Mixtures

#### Materials

<u>Station 1</u>	white sand clean bottles	white rice grains plastic spoons	rags strainer
<u>Station 2</u>	a glass of water table salt alcohol lamp matches	clean bottles stirring rod small beaker biscuit can cover	sand tripod rags
<u>Station 3</u>	ground charcoal stirring rod	2 clean bottles iron filings	magnet rags

#### Procedure

##### Station 1

1. Examine each sample of sand and rice grains. Name some properties of each. Prepare a Data Table for your observations.
2. Put a tablespoon each of sand and rice grains in a clean bottle and stir. Again observe the properties of sand and rice grains. Note down any changes that you see.
3. Describe some methods for separating sand from rice grains. Try the method that your group thinks is the most efficient, that is, will separate most of the sand from rice grains at the shortest time. Describe your results.
  - a. Were the properties of sand and rice grains changed when they were stirred together?

- b. If yes, how have they changed? Can you still recognize the sand particles? How about the rice grains?
- c. What was produced when sand and rice grains were mixed?
- d. What method did you use to separate sand from rice grains?
- e. Name some other methods that you can use to separate sand from rice grains? Which method is the most efficient?

### Station 2

1. Examine samples of water, sand, and table salt. Name some properties of each. Enter your data in your prepared table.
2. Half-fill a small beaker with water. Add, in small portions, half a spoon of table salt, stirring the water after each addition. Compare the appearance of salt before and after adding it to water.
3. Apply heat to the beaker and observe what happens with heating. Continue heating until half of the liquid is left in the beaker.
4. Repeat step 2 using sand instead of table salt. Compare the appearance of sand before and after adding it to water.
  - f. Did the properties of table salt and water change when they were stirred together?
  - g. If so, how did they change? Can you still recognize the salt crystals? How about the original water?
  - h. What was produced when salt was mixed with water?
  - i. What is left in the beaker? What was removed by heating?
  - j. What process occurred with continuous heating?
  - k. Did you observe the same change when sand was mixed with water? Explain your answer.

### Station 3

1. Examine samples of iron filings and ground charcoal. Name some properties of each. Enter your data in your prepared table.
2. Mix equal amounts of iron filings and charcoal. Stir well. Compare their appearance before and after mixing.
  - l. Did the properties of iron filings and charcoal change when they were stirred together? If so, in what way have they changed? Can you still recognize the iron filings? How about charcoal?
  - m. What was produced when iron filings and charcoal were mixed? Can the two be separated from one another?
  - n. What method did you use to separate iron filings and charcoal? Which of their properties did you consider in using the separation method?



What happens when heat is applied to a salt solution? The water gets separated from the salt through evaporation. This reveals that salt and water did not undergo any chemical change. They were physically combined and separated by a physical process.

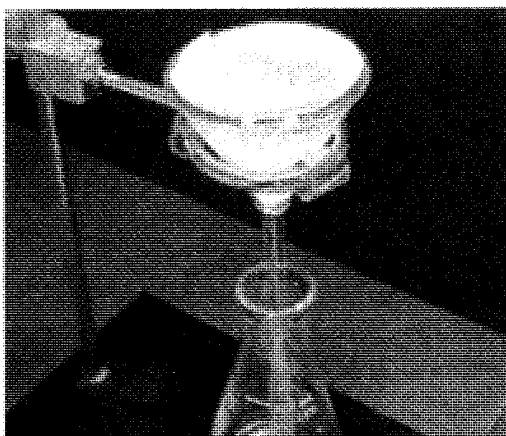


Figure.3.1 Simple filtration setup

Matter in the environment is mostly found in the form of mixtures. If you need the pure substances from the mixtures, you need to do some separation processes. Heterogeneous mixtures are often easier to separate than homogeneous mixtures because they are made up of large particles or layers. A mixture of solid particles in a liquid, as in the case of sand and water, can be separated by pouring the mixture through a filter that traps the solid particles and allows the liquid to pass through in a process called **filtration**.

Two layers of liquid, like oil and water, can be separated by pouring carefully the top layer into another container, called **decantation**. Another way is to allow the bottom layer to flow out into a receiving container using a special piece of laboratory glassware called a separatory funnel. Sand and water can also be separated through decantation.

Some simple methods are also used in separating homogeneous mixtures. A solid dissolved in a liquid solution can be separated by letting the solution dry out in the process called **evaporation**.

A homogeneous mixture of liquids with different boiling points can be separated by heating it up until it boils and condensing the vapor to give the purified distillate. The liquid with the lowest boiling point vaporizes and is condensed first; the liquid with the next lowest boiling point vaporizes and is condensed second; and so on. This process, called **distillation**, is most often used for purifying organic liquids and separating liquid mixtures.

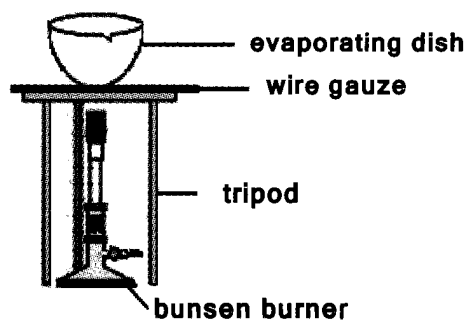


Figure 3.2 Evaporation setup

Heterogeneous solid mixtures, where one of the components can be attracted by a magnet, can be separated by the process of **magnetization**. This is applied in the iron filings-charcoal mixture. Iron is attracted to magnets but charcoal is not. In the case of sand and rice grains where neither is magnetic, some mechanical means like individual picking or sieving can be applied.

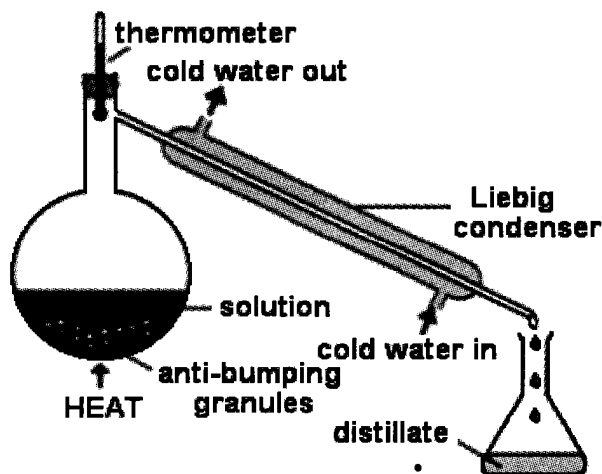


Figure 3.3 Simple distillation setup

## Differentiating Mixtures and Substances

Matter can be classified into two broad categories: pure substances and mixtures. You have compared the properties of the three kinds of mixtures. Do Activity 3.3 to find out how substances differ from mixtures.

### Activity 3.3 Differentiating Mixtures and Substances

#### Materials

##### Station 1

a bottle of sugar  
5 test tubes  
matches

alcohol lamp  
test tube holder  
rags

##### Station 2

a piece of potato  
butter knife  
matches  
rags

2 clean bottles  
barbecue sticks  
stirring rod  
hydrogen peroxide

#### Procedure

##### Station 1

1. Place a spoonful of sugar in a test tube. Observe its properties.
2. Heat the test tube for a few minutes and note down changes in color and odor of sugar.
3. Do you notice anything unusual on the side of the test tube? Describe your observations.

4. Light a match, let it burn for a while then blow it out. Take note of the smell and color of the burnt match. Compare it to the heated sugar.
  - a. What happens to sugar after heating it for a few minutes?
  - b. Describe the contents of the test tube. What is the substance left in the test tube?
  - c. Can you identify the droplets on the side of the test tube?
  - d. Can you recover the original white sugar crystals if you add water to sugar?
  - e. Describe the appearance of the burnt match. What dominant substance may be present in burnt match? Does it resemble the heated sugar?
  - f. Based on your observations, what substances are formed when sugar is intensely heated? Is sugar a substance or a mixture?

#### Station 2

1. Place a small amount of hydrogen peroxide in a clean bottle. Cut a small piece of potato then peel off its skin. Name some properties of water and potato.
2. Carefully drop the piece of potato into the bottle with hydrogen peroxide. Describe your observations.
  - g. Name some of the uses of hydrogen peroxide.
  - h. Describe what happens when potato is added to hydrogen peroxide. Can potato and hydrogen peroxide be separated after they have mixed?
  - i. Are there new substances formed? What could be these substances?

The fact that the components of a mixture can be separated by physical means indicates that the components are not chemically combined. They retain their individual identities when they are mixed. The quantities of the components may also vary depending on the mixture to be prepared. For example, salty water is a mixture of salt and water that looks like water but tastes like salt. If one sample of salty water for preserving food is saltier than another sample for cooking (just like water from the sea compared to water from a river) we know that the first sample has a greater amount of salt than the second. Mixtures, therefore, have variable compositions.

Substances may be classified into elements and compounds. By now, you know very well how heat affects sugar. When you apply heat on a sugar solution, water separates from sugar through evaporation. But when you apply heat on sugar alone, the sugar will break down or

decompose into simpler substances, namely, carbon dioxide gas, water vapor, and carbon black. Carbon, oxygen, and hydrogen taken singly are called elements. In combination with one another, they form compounds. Sugar, water, and carbon dioxide are compounds.

A substance is the same no matter where it is found. Sugar ( $C_{12}H_{22}O_{11}$ ), water ( $H_2O$ ), carbon dioxide ( $CO_2$ ), sodium chloride ( $NaCl$ ), and oxygen gas ( $O_2$ ) are all substances because their composition will be the same no matter where you find them. This applies to all known and existing compounds.

**Compounds** are substances that are made up of more than one type of atom. Water, for example, is made up of hydrogen and oxygen atoms. Carbon dioxide is made up of carbon and oxygen atoms. Table salt is made up of sodium and chlorine. Compounds differ from mixtures in that they are chemically combined. Unlike elements, compounds can be decomposed, or broken down by simple chemical reactions.

**Elements** are substances that are made up of only one kind of atom. They are considered as the simplest kind of matter. There are presently over 100 known elements, most of which are metals. Even atoms are made up of smaller particles, but they are not broken down by ordinary chemical means.

Q3.1 Give other mixtures that you see inside and outside your house or on your way to and from school. How can you determine whether or not the material you see is a mixture? Classify the mixtures into homogeneous and heterogeneous groups.

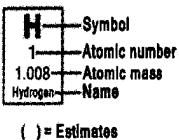
## Arrangement of Elements in the Periodic Table

Scientists have encountered hundreds of thousands of substances and as of 2007, they identified that only 117 of them are elements; all the rest are compounds. The symbols of these elements are given in the periodic table in Table 3.1.

The periodic table is made up of horizontal rows called **periods** and vertical columns called **groups or families** indicated by Roman numerals (I to VIII). A diagonal line near the right end of the table (from B to At) divides the metals on the left and the nonmetals on the right. Elements along the dividing line are called **metalloids**. The elements that are placed within groups and within periods have similar properties. Find out the similarities and differences of some elements in Activity 3.4.

**Table 3.1 Periodic Table of Elements**

1																	18	
1	<b>H</b> 1 1.008 Hydrogen																	<b>He</b> 2 4.00 Helium
2	<b>Li</b> 3 6.94 Lithium	<b>Be</b> 4 9.01 Beryllium											<b>B</b> 5 10.81 Boron	<b>C</b> 6 12.01 Carbon	<b>N</b> 7 14.01 Nitrogen	<b>O</b> 8 16.00 Oxygen	<b>F</b> 9 19.00 Fluorine	<b>Ne</b> 10 20.18 Neon
3	<b>Na</b> 11 22.99 Sodium	<b>Mg</b> 12 24.31 Magnesium											<b>Al</b> 13 26.98 Aluminum	<b>Si</b> 14 28.09 Silicon	<b>P</b> 15 30.97 Phosphorus	<b>S</b> 16 32.07 Sulfur	<b>Cl</b> 17 35.45 Chlorine	<b>Ar</b> 18 39.95 Argon
4	<b>K</b> 19 39.10 Potassium	<b>Ca</b> 20 40.08 Calcium	<b>Sc</b> 21 44.96 Scandium	<b>Ti</b> 22 47.88 Titanium	<b>V</b> 23 50.94 Vanadium	<b>Cr</b> 24 52.00 Chromium	<b>Mn</b> 25 54.94 Manganese	<b>Fe</b> 26 55.85 Iron	<b>Co</b> 27 58.93 Cobalt	<b>Ni</b> 28 58.89 Nickel	<b>Cu</b> 29 63.55 Copper	<b>Zn</b> 30 65.39 Zinc	<b>Ga</b> 31 69.72 Gallium	<b>Ge</b> 32 72.61 Germanium	<b>As</b> 33 74.92 Arsenic	<b>Se</b> 34 78.96 Selenium	<b>Br</b> 35 79.90 Bromine	<b>Kr</b> 36 83.30 Krypton
5	<b>Rb</b> 37 85.47 Rubidium	<b>Sr</b> 38 87.62 Strontium	<b>Y</b> 39 88.91 Yttrium	<b>Zr</b> 40 91.22 Zirconium	<b>Nb</b> 41 92.91 Niobium	<b>Mo</b> 42 95.94 Molybdenum	<b>Tc</b> 43 (97.9) Technetium	<b>Ru</b> 44 101.07 Ruthenium	<b>Rh</b> 45 102.91 Rhodium	<b>Pd</b> 46 106.42 Palladium	<b>Ag</b> 47 107.87 Silver	<b>Cd</b> 48 112.41 Cadmium	<b>In</b> 49 114.82 Indium	<b>Sn</b> 50 118.71 Tin	<b>Sb</b> 51 121.76 Antimony	<b>Te</b> 52 127.60 Tellurium	<b>I</b> 53 126.90 Iodine	<b>Xe</b> 54 131.29 Xenon
6	<b>Cs</b> 55 132.91 Cesium	<b>Ba</b> 56 137.33 Barium	<b>La</b> 57 138.91 Lanthanum	<b>Hf</b> 72 178.49 Hafnium	<b>Ta</b> 73 180.95 Tantalum	<b>W</b> 74 183.85 Tungsten	<b>Re</b> 75 186.21 Rhenium	<b>Os</b> 76 190.2 Osmium	<b>Ir</b> 77 192.22 Iridium	<b>Pt</b> 78 195.08 Platinum	<b>Au</b> 79 197.97 Gold	<b>Hg</b> 80 200.59 Mercury	<b>Tl</b> 81 204.38 Thallium	<b>Pb</b> 82 207.2 Lead	<b>Bi</b> 83 208.98 Bismuth	<b>Po</b> 84 (209) Polonium	<b>At</b> 85 (210) Astatine	<b>Rn</b> 86 (222) Radon
7	<b>Fr</b> 87 223.02 Francium	<b>Ra</b> 88 226.03 Radium	<b>Ac</b> 89 227.03 Actinium	<b>Rf</b> 104 (261) Rutherfordium	<b>Db</b> 105 (262) Dubnium	<b>Sg</b> 106 (263) Seaborgium	<b>Bh</b> 107 (262) Bohrium	<b>Hs</b> 108 (265) Hassium	<b>Mt</b> 109 (266) Meitnerium	Unnamed discovery 110 Nov. 1994	Unnamed discovery 111 Nov. 1994	Unnamed discovery 112 1996	Unnamed discovery 114 1999	Unnamed discovery 116 1999	Unnamed discovery 118 1999	Unnamed discovery 119 1999	Unnamed discovery 120 1999	Unnamed discovery 121 1999



<b>Ce</b> 58 140.12 Cerium	<b>Pr</b> 59 140.91 Praseodymium	<b>Nd</b> 60 144.24 Neodymium	<b>Pm</b> 61 (145) Promethium	<b>Sm</b> 62 150.36 Samarium	<b>Eu</b> 63 152.97 Europium	<b>Gd</b> 64 157.25 Gadolinium	<b>Tb</b> 65 158.93 Terbium	<b>Dy</b> 66 162.50 Dysprosium	<b>Ho</b> 67 164.93 Holmium	<b>Er</b> 68 167.26 Erbium	<b>Tm</b> 69 168.93 Thulium	<b>Yb</b> 70 173.04 Ytterbium	<b>Lu</b> 71 174.97 Lutetium
<b>Th</b> 90 232.04 Thorium	<b>Pa</b> 91 231.04 Protactinium	<b>U</b> 92 238.03 Uranium	<b>Np</b> 93 237.05 Neptunium	<b>Pu</b> 94 (240) Plutonium	<b>Am</b> 95 243.06 Americium	<b>Cm</b> 96 (247) Curium	<b>Bk</b> 97 (248) Berkelium	<b>Cf</b> 98 (251) Californium	<b>Es</b> 99 252.08 Einsteinium	<b>Fm</b> 100 257.10 Fermium	<b>Md</b> 101 (257) Mendelevium	<b>No</b> 102 259.10 Nobelium	<b>Lr</b> 103 262.11 Lawrencium

## Properties of Metals and Nonmetals

What is the difference between a milk can and an electric wire? How are they similar? Can you also give the similarities and differences between a rubber ball and a flagpole, and a gold ring and a carbon rod? Find out the properties that differentiate metals from nonmetals in the next activity.

### Activity 3.4 Metals and Nonmetals

#### Materials

empty milk can  
gold ring  
mortar and pestle  
carbon rod

hammer  
pair of scissors  
clothespin  
small bent nails

electrical wire  
paper clips  
alcohol burner  
banana leaves

### Procedure

1. Observe the color and feel the materials found in the tray. Present your data in a table form.
2. Manipulate the materials according to the questions 2a and write your answers in their respective rows. You may use the other materials in the tray.
  - a. Which of the materials
    - 1) are hard?
    - 2) can be straightened without breaking?
    - 3) can be folded?
    - 4) can be hammered into thin sheets?
    - 5) can be made into wires?
    - 6) can be cut with scissors?
    - 7) can be heated without changing into one or more different substances?
  - b. Based on your observations, what is the difference or similarity in properties between
    - 1) paper clip and electrical wire?
    - 2) paper clip and carbon rod?
    - 3) milk can and electrical wire?
    - 4) milk can and paper?
    - 5) electrical wire and gold ring?
    - 6) gold ring and carbon rod?
    - 7) carbon rod and banana leaf?
  - c. Give a brief explanation for the differences or similarities between each pair of material.
  - d. Which of the materials do you consider metals? Nonmetals? Explain your classification.
  - e. What other properties of metals and nonmetals can be used to differentiate them?

Electrical wire, paper clips, milk can, gold ring, and nails are all metals. Carbon is a nonmetal. Paper and banana leaves are combinations of certain compounds made up principally of carbon and oxygen, which are both nonmetals.

Most metals have the following characteristics:

- Ductile – able to be drawn into a wire.
- Malleable – can be hammered or pressed into thin sheets or desirable shapes without breaking.

- Luster (or lustrous) – the quality of shine from a reflected light.
- Conductor – can conduct heat and electricity without changing into a new substance.
- Hard and opaque.
- Denser than other elements.

Most nonmetals have the following characteristics:

- Brittle – easily broken or shattered into pieces. A piece of chalk, charcoal, or carbon rod shatters when a student accidentally steps on it.
- Insulator – does not conduct heat and electricity.
- Dull (or non-lustrous) – the quality, fact, or condition of absorbing light. All nonmetals have dull or non-lustrous surfaces.

The usefulness of metals and nonmetals depends on their properties. The ability of most metals to be drawn into wire and conduct electric current makes them suitable for electrical cabling and wiring. Electrical wires are made up largely of copper because copper is an excellent electrical conductor. It is less active than other metals and is not easily affected by water and most acids. Iron is used in cooking pans and flatirons because of its high heat conductivity. Aluminum is also used now in cooking pans. Its advantage over iron is that it is lightweight and does not form rust. Blacksmiths are able to make roofing sheets out of iron by hitting it with hammers because metals are malleable. Some roofing materials are made of iron as base metal coated with another metal that corrodes faster like aluminum and zinc. This process prevents iron from forming rust first. Metal coating is also done for aesthetics, versatility, and long-term performance of the metal. All metals, when polished, have very high versatility, and long-term performance of the metal. All metals, when polished, have very high luster. Gold is often used for making jewelry because of its attractive yellow color and luster.

The ability of nonmetals to prevent the flow or transfer of electricity and heat to other materials makes them effective insulators. Electrical wires are coated with non-conducting materials to prevent short circuits. They are wrapped with plastic or rubberized materials to prevent electrocution. Handles of cooking pans are also covered with rubber or special plastics to prevent the flow of heat from the cooking pan to the hands of the person cooking.

Q3.2 Identify the metals and nonmetals used in the following:

- household appliances,
- transportation,
- construction,
- computers and electronic devices,
- aerospace,
- communications, and
- biomedical applications.

Q3.3 Explain in terms of properties why metals and/or nonmetals are used in such applications.

## Acids and Bases

Another very important class of substances comprises the acids, bases, and salts. How significant are these substances to you? The words acid and base (an older term is alkali) are derived from direct sensory experience. Acid comes from the Latin word *acere* meaning "sour." You are familiar with common materials like *kalamansi*, *dalanghita*, green mango, tamarind, starfruit, tomato, and vinegar. They all contain acids that account for their sour taste. Aspirin tastes sour if you let it stay awhile in your mouth. The chemical name of its active ingredient is acetylsalicylic acid.

The word base, unlike acid, is not related to taste. All bases taste bitter. You probably dislike mustard and *ampalaya* because they taste bitter. Cough syrup and many medicines taste bitter. Manufacturers add sugar and other flavorings to medicines to hide the bitter taste of the active ingredients. Bases feel slippery, or as some people would say soapy. The reason is that bases can dissolve the oils from the skin and thus reduces friction between thumb and another finger as they are rubbed together. In essence, the base is making soap out of you. Detergent, ammonia water, and toothpaste contain bases that account for their bitter taste and slippery feel.

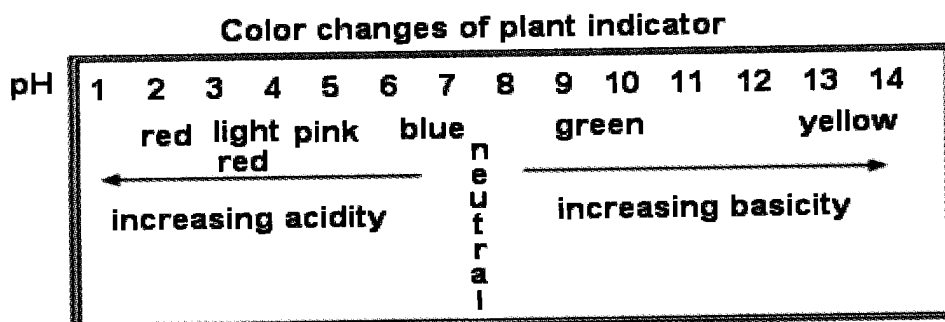
Acids and bases destroy each other's properties to produce a different substance, generally called **salt**. This type of reaction is called **neutralization**. Sodium chloride is a salt that is produced from the reaction of hydrochloric acid and sodium hydroxide.

A more precise way of distinguishing these two groups of substances is through their effects on indicators or the use of an instrument called pH meter. An **indicator** is a chemical that changes color when it is mixed with an acid or a base. Salt hardly affects an indicator. Ordinary tea is a good indicator. Make a cup of very dark tea, then squeeze fresh lemon juice into the tea as you stir it. Notice that the tea becomes lighter and lighter in color as lemon juice is added. Many colored plants are good acid and base indicators like red *mayana*, *gumamela*, and eggplant.

The common commercial acid-base indicators are litmus paper and the universal pH paper. Litmus paper changes color (blue or red) in the presence of any acid or base. pH paper has a wider range of color than litmus paper. Plant indicators approximate the pH range of the commercial pH paper.

Chemists use the **pH scale** to express how acidic (like an acid) or basic (like a base) a substance is. A pH value below 7 means that a substance is acidic, and the smaller the number, the more acidic it is. A pH value above 7 means that a substance is basic, and the larger the number, the more basic it is. The closer the pH of a substance is to zero, the more acidic it is. Conversely, the closer the pH of a substance is to 14, the more basic it is. A sample pH scale is given in Figure 3.4.





*Figure 3.4 pH scale*

Many acids and bases are corrosive; that is, they can dissolve or eat away substances by chemical action. For example, you can often see what looks like a white fungus around the wires of a car battery. This is corrosion caused by the extremely strong acid inside the battery. So you will have to be careful in using acids and bases provided in the next experiment. Find out how you can identify acids and bases in commonly-used materials.

### Activity 3.5 Testing for Acids and Bases in Common Materials

#### Materials

acid-base indicator	test tubes	stirring rod
4 sets petri dish	droppers	tweezers
test tubes	vinegar	toothpaste
shampoo	tap water	fruit juices
(different brands)	soft drinks	Alka-seltzer
detergent solution	fruits	

#### Procedure

1. Prepare as many test tubes as there are materials to be tested.
2. All the materials to be tested must be in solution form. Do not add water anymore to the liquid materials. If the material is solid, dissolve in a small test tube about  $\frac{1}{4}$  teaspoon of the material with 20 mL of water. Stir the mixture well to make sure that the solid dissolves completely in the water.
3. Test each liquid material by placing about 2 drops of it on an indicator paper. Let the indicator dry then paste it lightly on a piece of white paper.

The pHs of some common materials are shown in Table 3.2.

**Table 3.2 pH of Common Materials**

<b>Common Materials</b>	<b>pH</b>	<b>Common Materials</b>	<b>pH</b>
hydrochloric acid	0 – 3.0	urine, human	6.3 – 6.6
stomach acid	2.2 – 2.4	cow's milk	6.5 – 7.5
lemon juice	2.5 – 3.0	saliva, human	5.5 – 8.0
vinegar	2.0 – 4.0	drinking water	7.6 – 8.0
soft drinks	4.0	egg whites	7.3 – 7.5
tomato juice	4.0 – 5.0	blood, human	8.3
beer	5.0	seawater	9.0
rainwater (unpolluted)	6.0 – 6.6	baking soda	10 – 11
milk	4.8 – 6.4	ammonia	10.5
cheese	4.8 – 8.4	milk of magnesia	13 – 14
		sodium hydroxide	14.0

## Importance of pH

How does pH affect the body? Different aqueous solutions in various parts of our body have different pH values. Stomach fluids are strongly acidic due mainly to the presence of dilute hydrochloric acid. The pH of gastric juice is about 2. Acid conditions are needed for the digestion of proteins. Our small intestines need alkaline liquids for the complete digestion of foodstuffs. Blood is almost neutral. However, blood traveling from the heart to the lungs carries a lot of carbon dioxide. This makes the blood weakly acidic with a pH slightly less than 7. Our body fluids must be maintained at correct pH values in order to function properly.

How does pH affect the soil? The pH of the soil plays an important role in the growth of plants. It determines the availability of nutrients to plants. If the soil is too acidic or too basic, plants usually do not grow. Most plants require a pH of 7 to 8 to grow well. Lime, a basic substance, is sometimes added to an acidic soil to raise its pH or even neutralize it.

## Densities of Solids, Liquids, and Gases

By simply saying that the content of a glass is a colorless liquid is not enough to identify the liquid as water. You must describe other properties of water like it is tasteless and odorless; has a density of  $1.0 \text{ g/cm}^3$  (when pure); has a boiling temperature of  $100 \text{ }^\circ\text{C}$  and a melting temperature of  $0 \text{ }^\circ\text{C}$ ; and can dissolve many solutes. In identifying a given material, you should use in combination several properties or characteristics of the material.

Q3.4 Recall the properties of matter.

What will happen when a solid object is slowly lowered into the water? Recall that volume is the amount of space occupied by any object. All objects have volume. Thus, the solid object takes a portion of the space occupied by the water. What will happen to the water? We use the graduated cylinder to determine the volume of any liquid. How will you determine the volume occupied by the solid object?

**Mass** is the amount of matter an object has. We often use a beam balance to measure mass. How is mass and volume related? How is density of an object related to its mass and volume? Before you continue with this lesson, try to think of the answers to the following questions:

- Q3.5 A person who cannot float in a freshwater lake can float easily in the sea. What can be inferred about this in relation to saltwater?
- Q3.6 It is said that oil is lighter than water. Why does oil pose a great danger if it spills in a body of water?

### Activity 3.6 Density of Matter

#### Materials

small block of wood	ruler	piece of marble
balloon	oil	basin
graduated cylinder	water	beam balance

#### Procedure

##### A. Density of Solid

1. Measure the length, width, and height of a block of wood in cm.
2. Calculate the volume of the block in  $\text{cm}^3$ .
3. Measure the mass of the wood in grams using the beam balance. Record your data in a table form.
4. Determine the ratio of the mass to the volume of the block of wood. The ratio is the density of wood.
5. Based on the value you got in step 4, predict whether the block of wood will float on water or not.
6. Fill a basin with water. Carefully lower the block of wood along the side of the basin. What happened to the block of wood? Does your prediction match with your observation?
7. Determine the density of a piece of limestone by water displacement.
  - a. What is the density of the block of wood? Do solids have the same densities?

- b. What happens to the block of wood when it is placed in water? Give an explanation to your prediction.

**B. Density of Liquid**

1. Get some water. Measure its volume similar to what you did in procedure A. Measure the mass of the water sample. Calculate its density.
2. Repeat procedure B1 using oil instead of water. Compare its density with that of water.
  - c. Compare the densities of water and oil.
  - d. Why does oil float on water?

**C. Density of Gas**

1. Get the mass of an empty balloon. Inflate the balloon and measure its mass again. Compare the mass of the balloon with and without air.
2. Estimate the volume of air in the balloon and its density.
3. Compare the densities of different substances in Table 3.3.
  - e. Why does a balloon float on water?
  - f. Which of the substances in Table 3.3 would float in water?
  - g. Name the solids, liquids, and gases in Table 3.3. Compare the densities of gases with those of water.

You have seen that mass varies directly with volume and **density** is the amount of matter in a given volume. The density ( $D$ ) of a given material can be computed by dividing its mass ( $m$ ) by its volume ( $V$ ). The equation for the relationship is  $D = m/V$ .

If the mass is expressed in grams and volume in  $\text{cm}^3$ , the unit of density becomes  $\text{g}/\text{cm}^3$ .

The density of water in the metric system is  $1 \text{ g}/\text{cm}^3$ . This means that  $1 \text{ cm}^3$  of water has a mass of 1 g. Following this relationship, 10 g of water would have a volume of  $10 \text{ cm}^3$  and a volume of  $100 \text{ cm}^3$  would have a mass of 100 g. What would be the mass of  $50 \text{ cm}^3$  of water?

**Table 3.3 Densities of Common Materials**

Materials	Density, $\text{g}/\text{cm}^3$
cork	0.24
hydrogen	0.00009
concrete	2.3
ice	0.92
iron	7.8
balsa wood	0.13
lead	11.3
oxygen	0.0014
gasoline	0.68

Q3.7 Solve the following problems on density:

1. If the density of gold is  $19.3 \text{ g/cm}^3$ , what would be its mass if it occupies a volume of  $4 \text{ cm}^3$ ?
2. Compute the density of 10 g of carbon dioxide occupying a volume of  $5\,000 \text{ cm}^3$ .
3. A piece of aluminum has a mass of 96.5 g. When it was dropped into a graduated cylinder containing 50 mL of water, the water level rose to 85.0 mL. What is the density of aluminum?

Q3.8 Discuss the solution to the following problems:

1. If the density of a certain plastic that is used to make a bracelet is  $0.78 \text{ g/cm}^3$ , what mass would a bracelet of  $4 \text{ cm}^3$  have? Would this bracelet float or sink in water? Why?
2. Assume that the density of crude oil is  $0.93 \text{ g/cm}^3$ .
  - a. How come it is dangerous for oil to spill into a body of water?
  - b. How can the density of oil be an advantage in the clean-up?
3. How can a farmer apply the concept of density in selecting seeds that are most ideal for planting and growing?
4. Which has a greater density, 100 g of feathers or 100 g of iron?

Different substances have different densities. Materials that are less dense than water float on it. Materials that are denser than water sink in it. Generally, solids are densest while gases are least dense. Liquids are denser than gases but less dense than solids.

Q3.9. Knowing the concept of density is very useful in many ways. Name some of these uses.

## Lesson 3.2 Changes That Matter Undergo

Change is everywhere around you. A pencil gets broken. You cut paper into halves. Your butter is melting. Your milk has turned sour. The cake is being baked in the oven. The water is boiling. Outside, the leaves have turned brown, wood is rotting, clothes are drying, milk cans are rusting, tricycles are plying their usual route creating noise and emitting smoke—the list is almost endless. Change is inevitable.

There are two kinds of changes that matter may undergo—physical and chemical. You will learn about these changes in this lesson. You will differentiate these two changes and explain what happens as matter changes. You will also determine the effects of heat on these changes.

## Physical and Chemical Changes

You are familiar with water changing from solid to liquid and liquid to gas when heat is applied.

When you apply heat on ice, it melts into water. When you place the same water in a freezer, it solidifies. Water changes in state only. This kind of process is said to be reversible.

### Activity 3.7 Physical Changes

#### Materials

pieces of different materials:	ice cubes
paper, cloth, plastic	rubber band
transparent cup	modeling clay
metallic spoon	matches
blunt knife	candle

#### Procedure

1. Describe a piece of paper then tear it into small pieces. Do the same for the pieces of cloth and plastic.
  - a. How do the torn pieces look? Compare their characteristics with the original.
2. Describe the appearance of some ice cubes. Leave it on the container for a few minutes. Describe what happened to the ice cubes.
  - b. Was there a change in the ice cubes? Can the ice cubes be recovered? If so, state how.
3. Scrape the side of a candle wax and collect some pieces on to a spoon. Describe the wax pieces. Heat the spoon over a candle flame.
  - c. What happened to the candle wax? Are the characteristics of the candle wax the same before and after heating?
4. Describe the characteristics of a rubber band. Stretch it and keep it in place for a little while, then release it.
  - d. What happened to the rubber band? Did its characteristics change? If so, which characteristics?
5. Stretch the rubber band to the fullest until it snaps.

- e. What were the changes after the rubber was stretched?
6. Cut a small piece of modeling clay. Press it with your hands.
  - f. What are the changes in the modeling clay?
7. Mold the clay into another shape.
  - g. Does the clay possess the same characteristics as the original clay? Will changing its shape change the clay into another material?
8. Describe the appearance of some iron filings. Place some of the iron filings on a piece of paper and place a magnet near them.
  - h. What happened to the iron filings and the magnet?
9. Separate the iron filings from the magnet.
  - i. Describe any change on the iron filings and the magnet.
  - j. Was there a new material formed after each change?
  - k. When do we say that a change is only physical?

What are the foods that you ate today? Maybe you ate fried egg and fish with fried rice. Or fried chicken with newly cooked rice. Or if you are fond of sandwich, maybe you ate hotdog or chicken sandwich. How were the foods prepared? What are the changes that each food underwent during preparation? How can you tell when matter has undergone a chemical change? Find out the indicators of a chemical change in the following activity.

### Activity 3.8 Chemical Changes

#### Materials

a piece of <i>pan de sal</i> or any kind of bread	alcohol lamp	medicine dropper
pieces of eggshells	rags	denatured alcohol
evaporated milk	spoon	test tube holder
5 small clear bottles	eggplant	cutter or knife
white sugar	vinegar	a piece of potato
3% hydrogen peroxide	matches	measuring cup

#### Procedure

1. Changes on bread: Get a small piece of bread. With a test tube

holder, place it over a flame for a minute or two or until you see changes on the bread.

- a. Does the bread look the same as the original? Do you think you can recover the original characteristics of the bread?
2. Changes on eggshells and vinegar: Pour  $\frac{1}{4}$  cup of vinegar into a clear bottle. Drop a few small pieces of eggshells into the bottle. Observe the mixture.
    - b. What happens to the vinegar and the eggshells? Is there a new substance formed? If so, what do you think is this new substance?
  3. Changes on milk and vinegar: Pour  $\frac{1}{4}$  cup of vinegar into a clear bottle. Add about 20 drops of evaporated milk into the bottle. Observe the mixture.
    - c. What happens to the vinegar and the eggshells? What new substance was formed? Do you think you can still recover the original materials?
  4. Changes on sugar: Place some sugar on to a spoon. Wrap the handle of the spoon with a rag to avoid burns. Place the spoon over a flame for about 5 minutes.

Describe all the changes you observe on sugar. Continue heating until the color becomes almost black.

    - d. Are the characteristics of sugar the same before and after heating? Is it possible to recover the original sugar? Is the black substance formed still sugar?
  5. Changes on eggplant: Cut a small piece from the eggplant and observe its characteristics particularly the cut section. Leave this cut section exposed to the air. Observe it again after about 5 minutes.
    - e. Does the cut section have the same color as before? What do you think will happen if the eggplant is exposed for a longer time?
  6. Changes on hydrogen peroxide and potato: Pour  $\frac{1}{4}$  cup of hydrogen peroxide into a clear bottle. Add a small slice of peeled potato to the bottle. Observe the slice of potato for a few minutes and note down any change.



- f. What happens to the slice of potato? Is there any indication that another substance is present? What do you think is this substance?
- g. Which material underwent chemical change? Give your reasons for your choices.
- h. State the evidences that you must look for in a chemical change.
- i. State an operational definition of a chemical change.

A chemical change occurs when one or more of the following indicators are evident: a) new color appears, b) bubbles of gas evolve, c) a solid material (precipitate) forms in the liquid, and d) heat or light is given off. In all these four indicators, the change cannot be reversed. For example, bread undergoes chemical change when it turns black and hard like charcoal when placed over a flame. Bread cannot reverse back to its original softness, flavor, and taste.

Eggshell undergoes a chemical change when it reacts with vinegar. One of the visible products is the bubbles of gas (carbon dioxide) evolved during the reaction. The other product (calcium acetate) is in the solution. The reaction cannot be reversed so the original reactants (eggshells and vinegar) cannot be recovered.

Milk and vinegar react and form a cream-colored precipitate. This precipitate is insoluble so it just settles at the bottom of the container. It cannot return to its original form no matter how much shaking or stirring is done.

Sugar changes chemically to black solid (carbon) and some water vapor when strongly heated. The black solid cannot return to the original sugar even if it is immersed in water or heated in water.

The cut portion of an eggplant turns brown because of the chemical combination of oxygen with some chemicals in eggplant. It will become darker if it is left exposed to air for a long time. The sliced portion of a potato is acted upon by the oxygen from hydrogen peroxide. Hydrogen peroxide is a very unstable compound. The enzymes from potato easily break down hydrogen peroxide into oxygen gas and water. The rapid evolution of bubbles indicates the formation of oxygen gas, which in turn reacts with the potato. The browning of potato indicates a reaction with oxygen.

Q3.10 There are chemical changes which have useful and beneficial effects on humans. Name some of these changes and explain why you consider them useful and beneficial.

Q3.11 However, there are some chemical changes that have harmful effects to humans and properties. Name some of these changes and explain why you consider them harmful.

## Effect of Heat on Matter

During town fiestas, vendors take the opportunity to sell big, beautiful balloons. There are times, however, when vendors stand in corners and wait for customers under the heat of the sun for a long time. The overheated balloons would suddenly burst. Can you tell why this happens?

You have surely felt hot water coming out of hot springs. An egg dipped in boiling water is cooked in a few minutes. Heat caused the egg to be cooked. Have you watched an ice cube in your palm become smaller? The heat from your hand and from the surrounding air makes it melt. That is why you should never leave a bag of ice or a cup of ice cream outside the freezer for a long time.

Q3.12 You want to drink your coffee but it is still very hot. You decide to place it in a bowl with cold water. Why? What eventually happens to the coffee and to the cold water?

Can you say that heat is involved in a change, whether it is physical or chemical? Can we measure heat? How is it expressed? Do the next activity to help you answer these questions.

### Activity 3.9 Heat Involved in a Chemical Change

#### Materials

candle	beam balance	small beakers
water	small plastic saucer	thermometer
test tubes	10 mL graduated cylinder	test tube holder

#### Procedure

1. Get the combined mass of the candle and plastic saucer with a beam balance. Assign this as initial mass,  $m_1$ .
2. Pour 10 mL water into a test tube. Take the temperature of the water. Assign this as initial temperature,  $t_1$ .
3. Let the candle stand firmly on the saucer. Carefully light the candle, then hold the test tube with a test tube holder in the flame. Move the test tube gently in small circles while in the flame for even distribution of heat.

4. Continue heating for about 3 minutes. Take the temperature of water just before removing the test tube from the flame. Assign this as final temperature,  $t_f$ .
  - a. Which has a higher temperature, water before heating or water after heating? To what is the change in temperature due?
5. Put off the candle. Get again the combined mass of the candle and the saucer. Assign this as final mass,  $m_2$ . Calculate the mass of the candle after burning.
6. The heat produced by the burning candle is determined through the amount of heat absorbed by the water. Thus, the heat absorbed by water from the burning candle is equal to the product of the heat capacity of water ( $1 \text{ cal/}^\circ\text{C}$ ), the mass of water ( $D_{\text{water}} = 1 \text{ g/mL}$ ), and the change in temperature of water.

Material Observed	Initial Observations	Final Observations
Water	Initial temperature = Volume = Mass of water = ( $D = m/v = 1 \text{ g/mL}$ )	Final temperature = Volume = Mass of water ( $D = m/v = 1 \text{ g/mL}$ )
Candle	Mass of candle and saucer =	Mass of candle and saucer = Mass of candle burned

- b. Which has a higher temperature, water before heating or water after heating? To what is the change in temperature due?
- c. Which material produced heat? Absorbed heat?
- d. What happened to the mass of the candle after it was burned? What does this indicate, a physical change or a chemical change?
- e. How much heat is evolved in burning 1 g of candle?

A chemical reaction in which fuel combines with the oxygen in the air and gives off heat and light is called **burning** or **combustion**. You see this in the fire that is produced when a fuel is burned. You also notice other materials formed like gases in soot and smoke. In an open system, the fuel usually decreases in mass. Anything that will burn can be called **fuel**. In the case of your experiment, it is the candle, which served as fuel. Wood, paper, gasoline, and natural gas are examples of fuel. Food is also fuel that provides the body with the essential heat to keep it warm and maintain its normal temperature.

When an object is placed over burning fuel, the heat from the fuel is transferred to the object. The temperature of the object rises. Compared to the temperature of the candle flame which is very high, the temperature of water is considerably lower. However, the temperature of water rose after it had been heated by the burning candle. The increase in temperature is due to energy absorbed by water from that energy given off by the burning candle. Heat was transferred from the object with a higher temperature (candle) to the object with a lower temperature (water). Transfer of heat occurs only when there is a difference in temperature between two substances and the transfer is from a hot object to a cold one.

The amount of heat that the candle gave off, assuming that all of this heat was transferred to water, can be determined with a special apparatus called **calorimeter**. Then you use the data you obtained for water and apply the principle of heat transfer as in the equation below:

Heat given off by the candle = Heat absorbed by the water. In symbols,

$$Q_{\text{candle}} = Q_{\text{water}}$$

where Q stands for heat.

The amount of heat absorbed by the water is given by the relationship:

$$Q_{\text{water}} = m_{\text{water}} \times c_{\text{water}} \times (t_{\text{final}} - t_{\text{initial}})_{\text{water}}$$

where  $m_{\text{water}}$  = mass of water  
 $c_{\text{water}}$  = heat capacity of water  
 $(t_{\text{final}} - t_{\text{initial}})_{\text{water}}$  = change in temperature of water.

You can substitute the values for the mass of water, heat capacity of water, which is 1 calorie per gram per degree change in temperature given in degrees Celsius (1 cal/g C°).

Q3.13 Why is it that food rich in carbohydrates are called energy-giving foods? Give examples of carbohydrates.

Q3.14 What is the significance of water's high heat capacity in our body and in our environment?

### Lesson 3.3 Behavior of the Particles of Matter

What is common to wood, stone, water, and air? You have learned that they have common properties such as mass, volume, and density. You have also learned that a solid has a definite shape. A liquid and a

gas flow so they have no definite shape. Their shapes change with their containers.

Do you know what matter is made of? What you know about matter comes mainly from what you see with your eyes. Do you think you have seen everything about matter? Can you possibly know what your eyes cannot see? For example, you know that matter is made up of particles. Can you see these particles? Can you feel them? In this lesson, you will study the nature of the particles that make up matter. You will try to see beyond what your eyes see through another property of matter which you can neither feel nor see. You can infer on the nature of particles from their behavior.

## Movement of Molecules

Observe a tiny drop of water on a plastic surface. Suppose you were able to divide this tiny drop into two, then divide one-half into half again, and so on until the particle could no longer be subdivided, does it still have the properties of water? What could that particle be?

The smallest particle of a matter, which possesses the properties of that kind of matter, is called a **molecule**. The smallest particle, which has the properties of water is a molecule of water.

How do molecules of matter behave? Do the next activity and compare the movement of particles through different media.

### Activity 3.10 Movement of Molecules

#### Materials

1 slice of cooked <i>gulaman</i> or gelatin	bottle of <i>bagoong</i> medicine dropper	water teaspoon
watch with second hand	clear bottles	soy sauce
$\frac{1}{4}$ tsp of blue dye		

#### Procedure

1. Place a slice of cooked *gulaman* or gelatin on a plate. Sprinkle  $\frac{1}{4}$  tsp of blue dye on the surface of the *gulaman*. Record the starting time. Set the gelatin aside and observe how long it will take the blue dye to penetrate the gelatin. While waiting for the results, proceed to step B. Note down the movement of the dye.
  - a. What happened to the blue dye? Did you observe any change? Describe the change.
  - b. Did you see any change in the color of the *gulaman*? If so, what caused this change?

- c. Did your observations show that the blue dye spread in the *gulaman*? How long did it take the blue dye to spread down in the *gulaman*?
  - d. Infer a reason for the spread of the dye in the *gulaman*.
2. Place 2 drops of soy sauce into a half bottle of water. Record the time you dropped the soy sauce into the water. Observe the water for a few minutes without moving the bottle. Note down your observations.
    - e. What happened to the drops of soy sauce as they fell into the bottle of water?
    - f. What happened to the soy sauce and water after a couple of minutes?
    - g. How did the soy sauce spread out? How long did it take to spread completely?
    - h. Infer a reason for the spread of the soy sauce in water.
  3. Get a covered bottle of *bagoong*. Observe and describe the contents. Ask a group mate to sit about half a meter away from you. Tell her to record the time the moment she smells the *bagoong*. Record the initial time, then uncover the bottle.
    - i. What happened when the bottle of *bagoong* was uncovered?
    - j. How long did it take the odor to reach your classmate?
    - k. Is the smell of *bagoong* in the bottle the same as the smell that reached your classmate?
    - l. How long did it take the odor to reach you? How far were you from the bottle? Why did it reach both of you when you were in different places?
    - m. Give other examples of movement of particles in a liquid and in a gas.

In Activity 3.10, you observed matter spreading in a gas (air), in liquid (water), and in a solid (gelatin). From the observations, you can say that molecules move. They diffuse. The spreading of blue dye in *gulaman* is an example of diffusion of molecules in solid while that of soy sauce spreading in water is an example of diffusion of molecules in liquid. You observed that when you uncovered the bottle of *bagoong*, you and your classmate smelled the *bagoong*. The odor of *bagoong* reached your nose through diffusion of molecules in air which is a gas.

Q3.15 How would you define diffusion of molecules in terms of what you have observed in the activity?

Q3.16 Give an example of diffusion in a solid, a liquid, and a gas.

The blue dye can diffuse through the *gulaman* because there are spaces in the *gulaman* that we cannot see. The same is true for water

and air. The soy sauce spread in water because of the spaces in water. The odor of *bagoong* readily diffused in air because of the spaces in air. Based on these observations, it can be said that matter has spaces through which other matter can spread. Does matter move the same distance for the same length of time, that is, do molecules diffuse at the same rate?

Q3.17 Which took the longest time—diffusion in a solid, in a liquid, or in a gas? Which took the shortest time?

Q3.18 Based on how fast diffusion of molecules takes place, what can you infer about the size of spaces within a solid, a liquid, and a gas.

Diffusion was fastest in the gas and slowest in the solid. It can be inferred that spaces between molecules in a gas are larger than in a liquid or in a solid. Since the diffusion in a liquid is faster than in a solid, it can be inferred that the spaces between molecules in a liquid are larger than those in a solid. The spaces between the molecules of a solid are the smallest.

Recall that soy sauce dropped into the water spreads out in all directions: downward, sideward, and upward. Likewise, this happened with the blue dye in *gulaman* and the odor of *bagoong* in all directions. This is why you and your classmates smelled the odor of *bagoong* even if you were in different locations.

Robert Brown, an English botanist, was the first person to infer that molecules move. In 1827, he was observing pollen grains suspended in water under a microscope. The pollen grains moved randomly and continuously in all directions following a zigzag line like the one shown in Figure 3.5. This motion is now known as **Brownian motion**, named after him. He inferred that the pollen grains moved because they are being kicked about by the molecules of water, which must be moving randomly, too. If you observe a

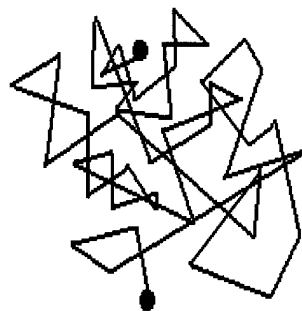


Figure 3.5 Brownian motion

sunbeam coming into your window early in the morning or a beam from a bus headlight at night, you will observe Brownian motion. If you look more closely, you will see small dust particles moving in all directions.

If the diffusing substance can move through a medium then there must be spaces between the molecules of the substances they are passing through. You can infer that the spaces between molecules are bigger if the passing molecules can move through it faster.

From the observation of Robert Brown that pollen grains move in zigzagging motion, it can be inferred that the molecules of water are also

in constant zigzagging motion. In fact, Activity 3.10 showed that molecular motion is fastest when the medium used is air (gas), slower in water (liquid), and slowest in gelatin (solid).

## A Model of the Molecules of Matter

Suppose you have just been to Manila and was asked by your classmates what Manila Zoo looks like, how would you describe it? You can describe the zoo in many ways. You can draw the zoo, or you can show pictures of the zoo. If you want to describe where the lions, the tigers, and the giraffes are located, you can make a layout of the zoo. The drawing, the picture, the miniature zoo, or the layout of the zoo, are examples of models.

You cannot see the molecules of matter nor the spaces between the molecules, but you can infer their presence. From your observations and inferences you can make a model. The model does not have to be a miniature or a layout, which can be seen. It can be a mental model. What is important is that your idea is made concrete and understandable with a model.

Scientists who have extensively studied the behavior of matter came up with a molecular model of matter. Matter is made up of molecules too small to be seen by the naked eye. These molecules are moving all the time, back and forth, up and down, in all directions but always in a straight line. Molecules of gases move faster than molecules of either liquids or solids. Molecules of liquids move faster than the molecules of solids. In solids, the molecules only move in their own place. They cannot move far. The molecules of liquids move far from each other while the molecules of gases move freely everywhere. Now you have a model that can help you explain your observations of diffusion.

Q3.19 Draw a model of the molecules of a gas, a liquid, and a solid.

Q3.20 Does your model convey what you have just observed?

Your model is good if it can explain what you observed. It is simple enough to enable you to use it and allow you to predict things that you have not seen, yet inferred all along. Figure 3.6 shows how a model of the molecules may look like.

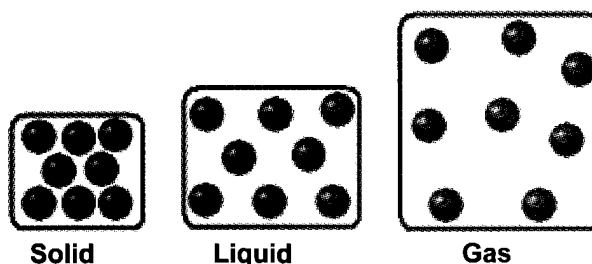


Figure 3.6 Molecules in a solid, liquid, and gas

You can liken the set up of molecules of matter to persons inside a crowded movie house. The movie house represents the volume occupied



by the molecules. Molecules of solids are like persons in a “standing room only” movie house. They stand close to each other as in solids.

Observe people in the market, moving from one stall to another in various directions, but not crowding each other. This is very similar to the movement of molecules of liquids. Molecules of gases, on the other hand, are like movement of basketball or football players scattered throughout the playfield and moving swiftly toward different directions at any given time.



(a)



(b)

*Figure 3.7 Analogy between people and molecules in (a) solid (b) gas*

- Q3.21 Based on these analogies and our model of molecules, explain why diffusion is slowest in a solid and fastest in a gas.
- Q3.22 How is it possible for you to predict what your mother is cooking even before you enter your house?
- Q3.23 Why can you identify the smell of perfume even though you are far from the opened bottle?

### **Using the Model to Predict Behavior of Matter**

Case 1: Molecules can be made to come close together. They can be compressed and held compact by applying force. The resulting volume would be smaller.

Case 2: In a given container, the molecules of gas are still far apart so that it is possible to add more gas molecules in it.

- Q3.24 Which of these situations (Case 1 or Case 2) occur when
- you put air into a flat tire or volleyball?
  - filling cooking gas cylinders? You can interview gas dealers on this question.
  - you press a soft balloon to change its shape?
  - you press a square piece of clay and it becomes smaller?
- Q3.25 Think of a way to explain why most solids do not change shape, while liquids and gases do.

## Like Molecules Attract

Examine the drops of water coming out of a faucet. Do the drops resemble water coming out of a medicine dropper? Why do the water drops look that way? Examine further how water looks like in the next activity.

### Activity 3.11 Surface Tension

#### Materials

glass of water	a needle	clean cloth or tissue paper
clean bowl	detergent solution	medicine dropper

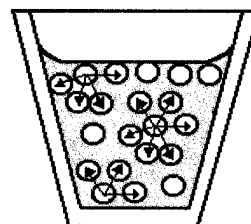
#### Procedure

1. Carefully pour water into a clean bowl.
2. Gently place a dry needle horizontally on the surface of the water. Observe what happens to the needle.
  - a. Does the needle float or sink in water? Explain your answer in terms of the molecular model.
3. Remove the needle from the water and wipe dry with a clean cloth.
4. Gently place the needle, vertically this time, into the water. Compare your observations here with the ones you made in step 2.
  - b. Does the needle float or sink in water? Explain your answer in terms of the molecular model.
5. Remove the needle again and wipe dry.
6. Now add 2 to 3 drops of detergent solution along one side of the bowl. Repeat steps 2 – 5. Observe what happens to the needle.
  - c. What happens to the needle after adding some detergent to water?
  - d. Have you watched insects called water striders play on the surface of a pond? What have you observed?

There are forces of attraction that exist between molecules. They are generally referred to as intermolecular forces of attraction. The attraction between molecules of the same kind is called **cohesion**.

Molecules that are closely packed have strong cohesive forces. Cohesive forces exist between water molecules. In the case of a drop of water, the attraction comes from all directions. See the arrows in Figure 3.8. A water molecule at the center pulls other water molecules towards it. This inward pull results in a cluster of water molecules with a small volume and an outer surface that is elastic and film-like.

Why did the needle float in water? Inside the glass, cohesive forces exist between water molecules. They attract each other. But the water molecules on the surface attract not only the water molecules beside them but also the water molecules under them. This attraction results in an elastic film or thin, rubber-like skin being pulled downward. This film is strong enough to support the needle and prevents it from sinking. The tightness of this surface is called **surface tension**.



*Figure 3.8 Cohesive forces between water molecules in a glass*

Surface tension explains why dust floats on water or why small insects can walk or stand on the surface of the water. They can remain on the surface because they are not heavy enough to separate and pass in between water molecules.

The needle however sinks in a solution of soap and water. The soap reduces the surface tension in the water by loosening up the molecular attraction or weakening the cohesive forces. In washing clothes with detergent solution, the water molecules are set “free” to penetrate very tiny pores in the clothes. For this, soaps are called “wetting agents.”

## Unlike Molecules Can Also Attract

What happens when water molecules come into contact with other kinds of molecules?

### Activity 3.12 Capillarity

#### Materials

3 transparent glass tubes (different diameters with the same length)  
a glass of colored water

#### Procedure

1. Label the glass tubes A, B, and C. Dip the tubes at the same time into a glass of colored water. Note down the amount of water that enters in each straw.

- a. In which tube did the water rise the highest? The lowest?
- b. Why are the levels of water different in the three straws?
- c. Why does the colored water rise in the tubes?
- d. Do the tubes and water have the same kind of molecules?
- e. In what other situations do you observe a liquid rising in a small tube?

The natural attraction between water molecules and a solid material is observed when water rises through a fine glass tube. The force of attraction between the molecules of both water and tube is greater than the force of attraction among water molecules and the pull of gravity. Hence, water rises through the fine tube. This is known as **capillarity**. The rise tends to be higher when the tube is narrow. This upward movement through a thin tube is called **capillarity action**. To understand it better, an analogy using children climbing ladders can be used.

Capillarity action also causes water to rise through porous materials like the soil. The tiny spaces between soil particles are much like the narrow tubes that bring the water up toward the surface of the soil, against the pull of gravity. The water then enters the thin hairlike root system of plants and passes through the plant's body, also by capillarity action.

Q3.26 Why is it faster to dry wet hair when rubbed with a towel than with a plain cloth?

Look closely from the side of the surface of the water in the tubes. The level at the center is lower than the level on the sides, near the glass. Earlier, you learned that cohesion is the attraction between like molecules such as that between water molecules. The strong attraction between water molecules on the water's surface and the water molecules under, below, and beside it causes the downward curve of the surface.

On the sides, water is in contact with the glass. The attraction between unlike molecules, like water and glass, is called adhesion.

In daily life, there are lots of examples of adhesion—paste sticks to paper, glue sticks to wood, chalk sticks to blackboard.

Q3.27 Why is it that wax paper does not get wet when you sprinkle water on it?

Wax sticks to the floor in the same way. It also makes the floor shiny and clean for a longer period of time. In some rural areas, people rub the underside of banana leaves on the floor to make it shiny. The underside of banana leaves contains natural wax.

## Lesson 3.4 Structure of Matter

Just like the elements, there are over 100 different kinds of atoms because elements are made up of atoms. Each atom, in turn, is made up of even smaller particles called **subatomic particles**. These subatomic particles are the electrons, protons, and neutrons. The **nucleus**, where the protons and neutrons are located, contains most of the mass of an atom and is positively charged. The **proton** is positively charged while the electron is negatively charged. The **neutron** is electrically neutral. The **electron** is located outside the nucleus and is much lighter than a proton. How are these particles arranged in an atom?

### A Model of the Atom

The Modern Atomic Theory is a result of the collective work of many scientists. The oldest theory was proposed by the Greek philosopher Democritus. The theory underwent many revisions as succeeding scientists devised new equipment and discovered new information. One of these scientists was John Dalton who gave us Dalton's atomic theory. John Dalton is considered as the Founder of the Modern Atomic Theory.

With more discoveries, Dalton's theory was modified. Notable among these modifications were Thomson's atomic model or "plum pudding model of the atom", Rutherford's atomic model, and Bohr's atomic model.

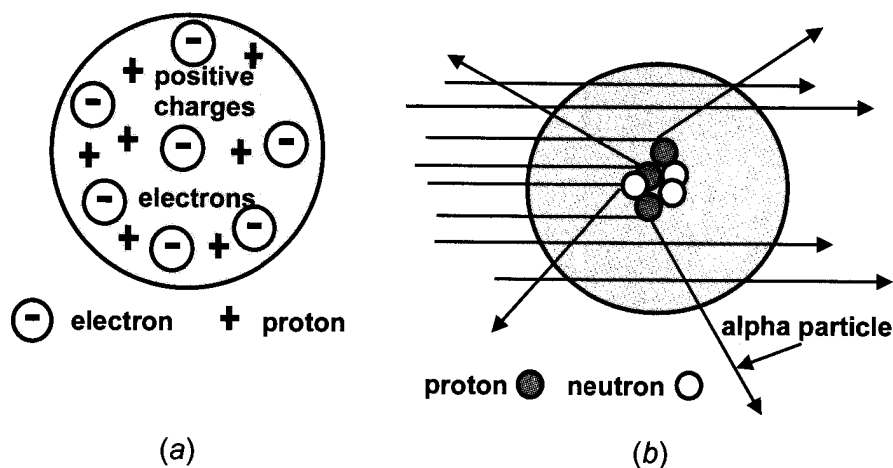


Figure 3.9 (a) Atomic models proposed by Thomson, (b) shows the experiment of Rutherford proving that the atom is almost entirely space except at the nucleus which contains the protons and neutrons.

Niels Bohr proposed a miniature solar system where the nucleus, containing the protons and neutrons, is located at the center of the atom. The electrons move in definite paths called **orbits** outside the nucleus. See Figure 3.10.

The Modern Atomic Theory is a modified version of the Bohr model. It shows the nucleus surrounded by a dense area resembling a cloud. Fast-moving electrons can be found in these clouds, hence the name electron clouds. The size or volume of an atom is determined by these electron clouds.

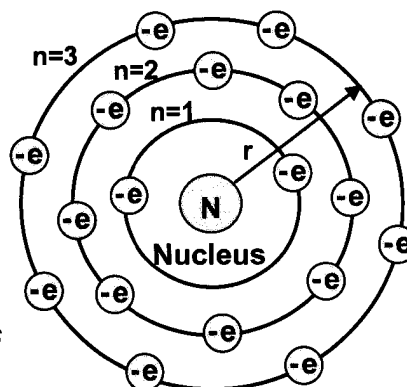


Figure 3.10 Bohr's model of the atom

## Symbols of Atoms and Molecules

You have seen in the Periodic Table of Elements that each element is represented by symbols. One kind of symbol uses one or two letters representing the name of the element. This symbol also represents an atom of the element. No two different elements have the same symbols. (Refer to the Periodic Table of Elements in Table 3.1, Lesson 1)

Another symbol uses numbers, representing the atomic numbers and atomic masses of the elements. The **atomic number** of an element corresponds to its number of protons in the nucleus or the number of electrons in its orbits.

Q3.28 Give the name of the element represented by each symbol and its number of electrons.

- |      |       |       |
|------|-------|-------|
| a. N | d. Pb | g. Cr |
| b. O | e. Hg | h. Ca |
| c. C | f. S  | i. Fe |

The present system of symbols was devised by Johann Jacob Berzelius. He used the first letter, or a combination of the first letter and another letter of the English, Latin, or Greek name to represent the element. Only the first letter is capitalized. The names were derived from different ways. Some were derived from their English names like hydrogen, carbon, nitrogen, and neon. Some were derived from their Latin or Greek names like cuprum for copper, argentum for silver, and ferrum for iron. Some were named from the places they were discovered: germanium from Germany, americium from America, polonium from Poland. A few were named after scientists: curium for Curie, einsteinium for Einstein, and mendelevium for Mendeleev. Refer to Table 3.4 for the names of some elements, their corresponding symbols and derived names.

Q3.29 What is used to represent a molecule of a compound? Give an example of a compound and how it is represented.

**Table 3.4 Names and Symbols of Some Elements**

Element	Symbol	Element	Symbol	Derived Name
Hydrogen	H	Copper	Cu	Cuprum
Helium	He	Gold	Au	Aurum
Carbon	C	Iron	Fe	Ferrum
Calcium	Ca	Lead	Pb	Plumbum
Cobalt	Co	Mercury	Hg	Hydrargyrum
Nitrogen	N	Potassium	K	Kalium
Neon	Ne	Silver	Ag	Argentum
Sulfur	S	Tin	Sn	Stannum

Recall your earlier definition of a compound. It is a substance composed of two or more kinds of atoms that are chemically combined. Thus, a compound is represented by a combination of two or more different symbols called **chemical formula**. The chemical formula tells us many things about the compound. For example, the chemical formula of sulfuric acid ( $\text{H}_2\text{SO}_4$ ) consists of the elements hydrogen, sulfur, and oxygen. It also shows that one formula unit consists of 2 hydrogen atoms, 1 sulfur atom, and 4 oxygen atoms. The subscripts give the number of atoms present in the formula unit. The atom ratio 2:1:4 is fixed and follows the **Law of Definite Composition**. The Law states that elements combine in a fixed ratio by mass to form a compound. Some examples of compounds are given in Table 3.5.

Q3.30 Give the name of each element, the corresponding number of atoms of each element in a formula unit, and atom ratio of the compounds in Table 3.5.

**Table 3.5 Some Common Compounds**

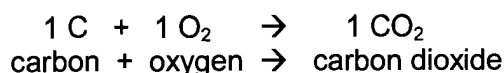
Common Name of Compound	Chemical Formula	Chemical Name
table salt	$\text{NaCl}$	Sodium Chloride
table sugar	$\text{C}_{12}\text{H}_{22}\text{O}_{11}$	Sucrose
limestone	$\text{CaCO}_3$	Calcium Carbonate
baking soda	$\text{NaHCO}_3$	Sodium Bicarbonate
lime	$\text{CaO}$	Calcium Oxide
wood alcohol	$\text{CH}_3\text{OH}$	Methanol
sand	$\text{SiO}_2$	Silicon dioxide
vinegar	$\text{CH}_3\text{COOH}$	Acetic acetate
pyrite	$\text{FeS}_2$	Iron (IV) Sulfide

## Simple Chemical Reactions

Scientists use a method of representing the chemical combination of two or more elements or compounds to form new elements or compounds. It is called chemical reaction and is represented by a

chemical equation. Symbols of elements and formulas of compounds are used in place of their names.

In a chemical equation, the reacting substances (called **reactants**) are written on the left side while the new substances formed (called **products**) are on the right side. Reactants and products are separated by an arrow to show the direction of the reaction. For example, carbon dioxide is formed when carbon chemically combines with oxygen gas. The reaction can be represented with the following equation:

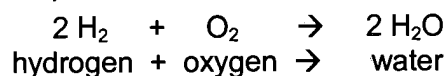


The equation reads: 1 molecule of carbon reacts with 1 molecule of oxygen forming 1 molecule of carbon dioxide. The coefficients represent the number of molecules of the substances. The equation follows the Law of Definite Composition. The subscript in each formula represents the number of atoms present in a molecule of the substance.

- Q3.31 Based on the equation, how many atoms of carbon are in a molecule of carbon? How about a molecule of oxygen? How about a molecule of carbon dioxide?
- Q3.32 Compare the total number of atoms of each element in the reactants with those of the products. Is the total number of atoms the same or different?

In a chemical reaction, the number of atoms of each element in the reactants is the same as the number of atoms of each element in the products. No new atoms were added or removed. Thus, the number of atoms of each element involved in the chemical reaction is conserved. Since atoms have masses, the mass of the reactants is the same as the mass of the products. This is the **Law of Conservation of Mass**.

Consider the formation of water from the reaction of oxygen and hydrogen, as in the equation below:



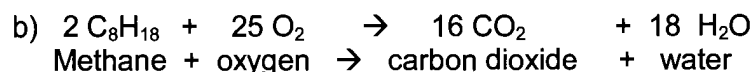
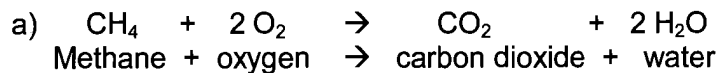
- Q3.33 What are the reactants and the products in the equation?
- Q3.34 What does the equation tell about the number of molecules of hydrogen and oxygen reacting to form water? What is the ratio of the reacting molecules?
- Q3.35 Compare the number of atoms of the reactants with those of the products. What does this indicate?

Thousands of chemical reactions are taking place around you: the rusting of metals like iron in household appliances and vehicle parts; the decay of food, leaves, and waste materials; formation and chemical weathering of rocks, burning of fuels that result in air pollution, and many, many more.

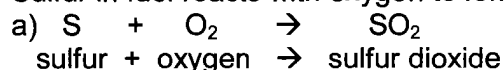


Below are equations for some common reactions in the environment.

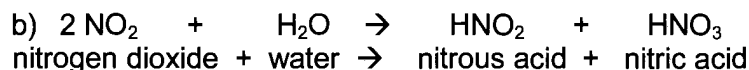
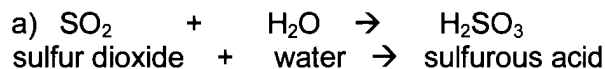
1. Burning of fuels releases gas pollutants into the atmosphere.



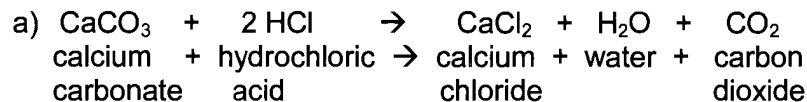
2. Sulfur in fuel reacts with oxygen to form sulfur dioxide.



3. Acid rain results when much sulfur dioxide are dissolved in water forming sulfurous acid. Nitrogen oxide reacts with water to form nitric acid.



4. Decay of limestone structures like cave, monuments, and buildings by acids.



Q3.36 What are the reactants and the products in each reaction above?

Q3.37 Name the elements and the number of atoms of each element in reactions 1 to 4.

Q3.38 What does each equation tell about the total number of atoms of each element in the reactants as compared to those of the products? Do the reactions follow the Law of Conservation of Mass?

## SUMMARY

Matter can be classified into different ways. One way is according to whether it is living or nonliving. Matter is classified as living if it breathes, moves, eats, grows, responds to things and situations around it, and has the ability to reproduce its own kind. Without these characteristics a piece of matter is considered nonliving.

Matter can also be classified into two broad categories: mixture and pure substance. A mixture may be homogeneous and heterogeneous. Homogeneous mixtures are uniform throughout. The composition is the same in all directions in the mixture. Heterogeneous mixtures are not uniform. The components of a mixture are called solute and solvent. Normally, the component with the greater amount is considered the solvent. The solute has lesser amount and is the one that dissolves in the solvent. These components can be separated through physical processes such as filtration, decantation, evaporation, and distillation.

Unlike mixture, a pure substance has only one component and this component has fixed composition. It is made up of either one kind of element or one kind of compound (made up of two or more different elements that are chemically combined). A pure substance is the same no matter where it is found such as gold, copper, oxygen, water, and carbon dioxide.

A pure substance may also be classified into elements and compounds. There are over 117 elements known today and arranged in a systematic way in what is called the periodic table. The periodic table is made up of horizontal rows called periods and vertical columns called groups (or families). A slanting diagonal line near the right end of the table (from B to At) divides the metals on the left and the nonmetals on the right. Elements along the dividing line are called metalloids.

Most metals are ductile, malleable, hard, lustrous, and good conductors of heat and electricity. Most nonmetals, on the other hand, are brittle, dull (nonlustrous), and poor conductors of heat and electricity. Their usefulness depends on these properties.

Another very important class of substances is the acids, bases, and salts. They can be distinguished from one another through their effects on chemical indicators like litmus paper or universal hydron (pH) paper. Chemists use the pH scale to express how acidic (like an acid) or basic (like a base) a substance is. A pH value below 7 means that a substance is acidic, and the smaller the number, the more acidic it is. A pH value above 7 means that a substance is basic, and the larger the number, the more basic it is. The closer the pH of a substance is to zero, the more acidic it is. Conversely, the closer the pH of a substance is to 14, the more basic it is.

Density is a property of substances that can be used to differentiate different substances. Different substances have different densities. Materials that are less dense than water float on it. Materials that are denser than water sink in it. Generally, solids are densest while gases are least dense. Liquids are denser than gases but less dense than solids.

There are two kinds of changes that matter may undergo—physical and chemical. A chemical change occurs when one or more of the

following indicators are evident: a) new color appears, b) bubbles of gas evolve, c) a solid material (precipitate) forms in the liquid, and d) heat or light is given off. If these four indicators are observed, the change cannot be reversed.

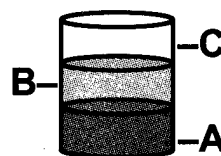
Chemical changes involve chemical reactions which are usually represented by chemical equations. Chemical equations follow the Law of Definite Composition and Law of Conservation of Mass.

## SELF-TEST

### I. Multiple-Choice Items

Choose the letter of the correct answer.

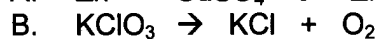
- You can pump additional air into a tire that is already with air. Which is the most appropriate explanation for this observation?
  - The molecules in gases are widely separated.
  - The molecules in gases have very high pressure.
  - The molecules in gases can spread evenly over an available space.
  - The molecules in gases move slowly throughout a given medium.
- A, B, and C are three immiscible liquids. When placed in a beaker, they occupy the positions indicated at right. Which of the following can be concluded?
  - A is the densest of the three liquids.
  - C is the least dense of the three liquids.
  - B is denser than C but less dense than A
  - B is denser than A but less dense than C.
- When you apply a few drops of alcohol on your hands, the spot feels cool while the alcohol is evaporating. Which statement below accounts for this observation?
  - The heat from the skin was absorbed by alcohol.
  - The alcohol has lower temperature so it feels cool on the skin.
  - The heat from the skin was used to separate the alcohol molecules.
  - The amount of heat possessed by the body is lower than the amount of heat possessed by alcohol.



## II. Open-ended or Constructed - Response Items

Answer the following.

1. Describe a method of separating the components of the following mixtures:
  - (a) pepper, garlic, and salt;
  - (b) flour and rice grains;
  - (c) iron filings and charcoal.
2. Based on your observations, give two differences and two similarities in properties between:
  - (a) paper clip and carbon rod;
  - (b) milk can and electric wire;
  - (c) water and alcohol.
3. Briefly explain why raincoats are usually made of plastics.
4. Give the name of each element and the corresponding number of atoms in a formula unit of the following compounds:
  - (a) limestone,  $\text{CaCO}_3$ ;
  - (b) vinegar,  $\text{CH}_3\text{COOH}$ ;
  - (c) sulfuric acid,  $\text{H}_2\text{SO}_4$ ;
  - (d) limewater,  $\text{Ca}(\text{OH})_2$ .
5. Examine the chemical equations below:



- (a) Compare the number of atoms in the reactant side and in the product side.
- (b) Write Yes if the number of atoms of the elements are equal on both sides and No if the number of atoms of the elements are not equal on both sides.
- (c) If your answer is no, explain why.

## Unit IV

### Force and Energy



The planets and their moons, the sun, the stars, and other heavenly bodies, though countless, move in this vast universe in harmony. The force that keeps them in their respective positions is just one of nature's fundamental forces. What are the other fundamental forces of nature? These fundamental forces account for the many things that you observe and cannot observe with your naked eye. What could these forces do?

You can walk and run. Other objects can also move. Force enables you and other objects to move. What is the nature of force?

You can move because you have energy. All other things on Earth move and function because they too have energy. What is the main source of the energy that you use at home?

## Lesson 4.1 Effects of Force

Look around you. What do you see happening because of force? Is there force acting on you now? Can you be where you are or do whatever you are doing now if it were not for force?

### Activity 4.1 What Can a Force Do?

#### Materials

rubber ball                      rubber band

#### Procedure

1. Hold a rubber ball and push it inwards with both hands.
  - a. What is the effect of your “push” on the ball?
2. Pull apart the ends of a rubber band.
  - b. What change does your “pull” do on the rubber band?
  - c. What is the other word for a “push” or a “pull”?
3. Place the ball on a table. Push it forward.
  - d. What happens to the ball? What makes it move?
4. Now roll the ball. While rolling, give it another push to the right.
  - e. What happens to the direction of motion of the ball? What changes its direction of motion?
  - f. What is the direction of the force exerted relative to the ball’s original direction of motion?
5. With your hand, stop the ball.
  - g. What stops the ball? What is the direction of the force relative to the ball’s direction of motion?
  - h. Summarize the effects of force that you observed.

You can change the shape of a pillow by exerting force on it. A spring is stretched when pulled and is shortened when pushed or compressed. A tree is bent by the force of the wind. When the shape of an object is changed, the object is said to be deformed. Objects are deformed when acted upon by an outside force. Even the toughest steel can be deformed, though very slightly.

Force deforms an object and changes its motion. A change in motion can be a change in the direction of the motion of the object or a change in how fast it moves. The quantity that specifies how fast an object moves is

called **speed**. An object's speed increases if the force applied to it is in the same direction as the original motion. Its speed decreases or the object may even stop or reverses direction if the force applied is opposite its direction of motion. If the force is perpendicular to the object's direction of motion, the object changes direction.

So when you see an object that is being deformed or its motion is changing then you are sure that there is force acting on it.

## Lesson 4.2 Fundamental Forces in Nature

There are four forces of nature. The two that are more familiar to everyone are the gravitational and the electromagnetic forces. The effects of these two forces in daily life are very evident. The other two forces are the strong and weak nuclear forces. These are significant in the realm of the atom.

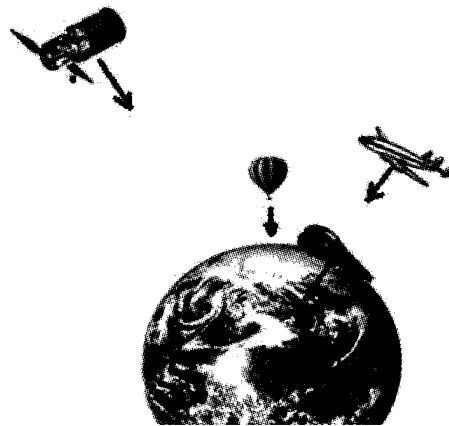
### Gravitational Force

Do a simple activity. Hold a coin. The coin in your hands is at rest; its speed is zero. Release the coin and observe its speed as it goes down. Compare its speed when it starts to fall and before it hits the floor.

The coin's speed increases as it falls. As such, there must be force acting on it. This force is Earth's gravitational force! **Gravitational force** is one of nature's four fundamental forces.

Earth's gravity exerts force on all objects at its surface, near its surface or far from it, moving or not moving, in a direction towards Earth's center. Thus, it attracts objects to itself so that they are prevented from floating; it makes an object thrown horizontally follow a curved path. Gravitational force is always an attractive force.

Every object can exert gravitational force that is dependent on its mass. The greater its mass, the greater is its gravitational force. This explains why the sun can exert a greater gravitational force than the moon. It is the sun's gravitational force that keeps the planets in their orbits. But it is Earth's gravitational force that keeps the moon and other Earth's artificial satellites in their orbits. It is gravitational force among the



*Figure 4.1 Earth's gravity acts on all objects.*

heavenly bodies that keep them in their respective places. So even with their multitude and the vastness of the universe, they are all kept in place because of gravitational force. Isn't this an awesome force?

### **Mass and Weight**

Mass and weight are two different quantities. **Mass** is the quantity of matter an object has while **weight** is the measure of the gravitational force on the object. The mass of an object remains constant wherever the object is, while its weight varies depending on its distance from Earth. The farther the object is from Earth, the less is its weight. The weight of an object is equal to the force of gravity exerted on that object at that point.

Mass is expressed in kilograms while weight is in newtons. Mass is measured using a beam balance while weight by a spring balance or a weighing scale.

You must have noticed that some weighing scales, especially those found in the market give readings in kilograms not in newtons. These should be more correctly calibrated in newtons. However, when you buy fruits, vegetables, meat, or fish you are more interested in knowing the quantity of the commodities that you are buying and not how much force Earth is exerting on them. So instead of expressing the readings of the weighing scale in newtons, they are instead calibrated in kilograms. This is possible since mass and weight are related by the following equation: weight ( $W$ ) = mass ( $m$ ) x acceleration due to gravity ( $g$ ) or

$$W_g = mg.$$

In one place, acceleration due to gravity ( $g$ ) is constant. It is about  $9.8 \text{ m/s}^2$ . So if the weight is known, then the mass can be calculated. Market spring balance is calibrated considering this factor.

It was mentioned earlier that the force of gravity on an object changes as it is brought nearer or farther from the center of Earth. This is due to the variation of the value of  $g$ . The value of  $g$  decreases as the distance from Earth increases. There is a very small variation of  $g$  though at sea level to the top of a mountain. So 1 kg of cherries in Baguio City is still 1 kg in the lowlands.

### **Measuring Force**

Bring your right hand at elbow level. Using your left hand put a notebook on your right hand. Feel the force that you exert on the notebook. Add five notebooks or a big book on your right hand. Compare the forces that you exert on one book and on six notebooks. Do you think your right hand can support a sack of rice? Why? The force you exert on the notebooks is the force needed to support them to keep them from falling. This force is needed to counteract the force of gravity (Figure 4.2).



The greater the mass of the object, the greater is the force required to support it.

How is force measured? Recall that force on an object can deform its shape. The more an object gets deformed, the greater is the force acting on it. This is true for a spring as shown in Figure 4.3.

A good force measurer is one which when the force is removed the measurer returns to its initial state; in the case of a spring, to its initial length. A specific force corresponds to a specific change in length of the spring.

Can you think of other force measurers? Bathroom scales and weighing scales used in the market are also force measurers. They have springs that can be stretched or compressed.

The unit of force is the newton (N) named in honor of Sir Isaac Newton, where

$$1 \text{ newton} = 1 \text{ kilogram metre/second}^2 \text{ or } 1 \text{ N} = 1 \text{ kg m/s}^2.$$

You can now perform Activity 4.2. Remember that when you hang mass on the spring balance, the reading indicated on the balance is the force exerted on the spring, which for a body at rest is equal to the force of gravity. The reading on the balance is the weight of the object.

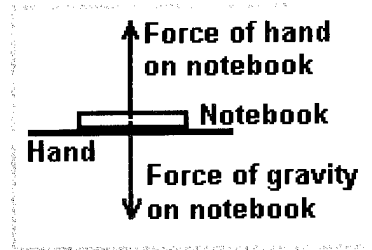


Figure 4.2 The force of the hand on the notebook is equal to the force needed to support it from falling.



Figure 4.3 Spring balance

### Activity 4.2 Measuring Force

#### Materials

block of wood	string
sticky tape	3 standard masses
2 spring balances (units in newtons)	(depending on the limits of your spring balance)
with different capacities or limits	

#### Procedure

1. Examine the two spring balances. Call the spring balance with less

maximum loading capacity A and the other B. Compare the springs that A and B have. Also observe the other features of the spring balances.

- a. What feature of the spring balance ensures that it cannot be overloaded?
2. Hang one standard mass on the spring balance. Record the spring balance reading in a table form.
  3. Do the same for the second and third masses. The third mass is a combination of any two masses.
    - b. Express mass in kilograms. Compare the masses of the different objects to their corresponding weights (in newtons).
    - c. Estimate the common factor to relate these two quantities.
    - d. How is the common factor called?

Greater force is needed to stretch a stiffer spring. A spring balance that has greater capacity should then have a stiffer spring than one which has less capacity.

## Electromagnetic Force

Electromagnetic force includes magnetic force and electrostatic force. Do Activity 4.3 to learn more of these forces.

### Activity 4.3 Magnetic Force

#### Materials

2 bar magnets  
paper clip  
pins

paper bits  
iron filings  
cardboard

nails  
toothpick  
plastic sheet

#### Procedure

1. Put all materials except the magnets in one place. Bring the magnet near the materials.
  - a. Examine the materials that are attracted to the magnet and those that are not? What kind of materials is attracted to the magnet?
2. Put one paper clip on the table. Bring the magnet near but not touching the clip.

- b. Does the magnet exert force on the paper clip even if they are not touching each other? How do you know?
3. Determine the maximum distance that a magnet can exert force on the paper clip. You can do this by slowly moving the magnet toward the paper clip.
  - c. What is the maximum distance between the tips of the paper clip and the magnet where the magnet can still attract it?
  - d. Shorter than this distance, can the magnet exert force on the paper clip? Why do you say so?
  - e. Longer than this distance, can the magnet exert force on the paper clip? Explain your answer.
4. Examine and note the marks at each end of the magnet. Discover how two magnets interact by bringing their ends together.
  - f. Summarize your observations on how the two magnets interact.
5. Now put a cardboard on top of a bar magnet. Sprinkle iron filings thinly on the cardboard. What do you see?
  - g. What does the pattern formed by the filings on the cardboard indicate?

The magnet that you used is a permanent magnet. The materials attracted to the magnet are called **magnetic materials**. When a magnet is placed near but not touching a small stationary magnetic material, it moves towards the magnet. The magnet therefore must have exerted a force on the magnetic material. This is called **magnetic force**. The magnet can exert force on a magnetic material even when they are at a distance. When the distance between them is shorter, the magnet more readily pulls the magnetic material. The force that can be exerted on a magnetic material is dependent on its distance from the magnet. This is also true for gravitational force. The farther an object is from Earth, the less is the gravitational force that it experiences as compared to when it is on Earth's surface.

Each end of a magnet behaves differently. Any magnet, regardless of its size and shape, has a north pole (N-pole) and a south pole (S-pole). Like poles of any two magnets repel each other while unlike poles attract. Thus, a magnetic force can either be attractive or repulsive. This is not so with gravitational force. Gravitational force is always attractive. So Earth never pushes any object away from it. If an object goes farther from Earth, this means that there is another force much greater in strength that counteracts gravitational force.

Iron filings are magnetic materials. The fact that they form a pattern when sprinkled over the cardboard on top of a magnet shows that the

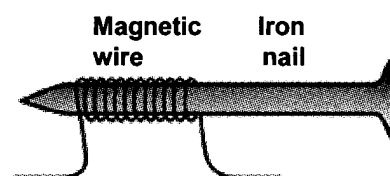
magnet affects the filings. At some distance from the magnet the iron filings are no longer affected. The region around which a magnet can exert force on magnetic materials is called its **magnetic field**.

A mass has also its own gravitational field. The greater the mass, the farther is the extent of this field. Can you now explain why Earth can exert force on a satellite which is very far from it?

Earth is a giant magnet. It interacts with other magnets such as a compass needle. This is the reason why the compass needle is always aligned along the N-S direction of Earth. Do you know that it is because of Earth's magnetic field that electric charges from outer space are trapped especially near Earth's poles? Auroras in the poles display the presence of these charges.

The nail-coil assembly (Figure 4.4) is called an electromagnet because it exhibits magnetism when there is electric current in the coil. When the electric current in the coil of the electromagnet is switched off, its magnetism stops. This is the basic difference between an electromagnet and a permanent magnet. The magnetism of a permanent magnet cannot be switched off.

However, an electromagnet and a permanent magnet have properties in common. An electromagnet, like a permanent magnet, has two poles. These interact in much the same way as in a permanent magnet; like poles repel, unlike poles attract.



*Figure 4.4 An electromagnet*

But electromagnets have some advantages over permanent magnets. The strengths of their magnetism can be varied depending on the amount of current electricity in the coil and the number of turns the coil has. The greater these two are the greater is the magnetism of the electromagnet. The strength of the electromagnet also depends on the nature of the core, which in your setup is a soft iron (nail). If you used other materials like wood or plastic, the pins or nails could have not been picked up. These materials cannot increase the magnetism setup by the current-carrying coil. Iron core can increase it by a thousand times! The N-pole or S-pole of an electromagnet can be interchanged depending on the direction of current in the coil.

Electromagnets have many applications. Electrical energy devices with moving parts have electromagnets. Examples are the electric fan, washing machine, blender, and doorbell.

Try rubbing a plastic sheet with tissue paper or cloth then bring it near your hair. What do you observe? Your hair is attracted to the rubbed plastic sheet. This is an example of an **electrostatic force**.

Frictional force, the force that resists motion, somehow falls under this force. It could be due to electrostatic forces between the particles of sliding surfaces that cause friction.

- Q4.1 Which field of Earth enables us to do or see the following: (a) use compass to find direction, (b) launch a satellite to circle Earth, (c) walk on the ground, and (d) presence of auroras in the sky?

## Friction

Why are some objects easier to push or pull than others? When you push a book on a table, it eventually stops. You must have learned in your elementary years that friction causes it to stop. Recall that there are three types of friction: static, sliding, and rolling friction. What factors affect frictional force? What is the difference between static and sliding friction? Do Activity 4.4.

### Activity 4.4 Factors That Affect Friction

#### Materials

block of wood with hook      spring scale      table  
sandpaper

#### Procedure

##### Part A

- Cover one side of the wood with sandpaper.
- Position the wooden block on the floor or tabletop with the sandpaper's rough side in contact with the floor.
  - Is there friction between the block of wood and the tabletop while the block is simply at rest?
- With the spring balance, pull the wooden block by 1 N.
  - In this case, is there friction between the block of wood and the tabletop? If there is, what is the amount of the frictional force?
- Slowly increase the force of your pull on the wooden block until the block starts to move. Note the maximum amount of pull attained before the wooden block starts to move.
  - What happens to the frictional force between the wooden block and the floor as you increase your pull on the block?

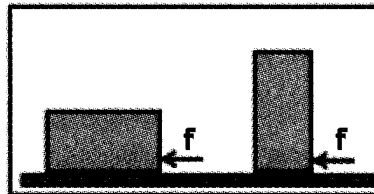


### Part B

5. Now, pull the wooden block by the hook at constant velocity. Tabulate your readings on the spring balance. Make two trials. Get the average.
6. Turn the block over so that the sandpaper side is on top while the smooth surface is in contact with the floor. Repeat step 5.
  - d. What quantity is varied in steps 5 and 6? Compare the amount of force needed to pull the wooden block in each case.
  - e. Which type of surface requires greater force? What factor do you think produces the difference?
7. Put a 1-kg mass on the block having the same position as in step 6. Repeat step 5.
  - f. What quantity is varied in steps 6 and 7? Compare the amount of force needed to pull the block in each case. What do you think causes the difference?
  - g. The force registered on the spring balance is the sliding friction between the block of wood and the tabletop or floor. What are the factors that affect sliding friction?

There is no friction between the block of wood and the tabletop while the block is simply at rest as in step 2. However, when the block is pulled (steps 3 to 4) and it still does not move, friction between it and the tabletop exists. This friction is called **static friction**. The amount of static friction increases from zero to a certain maximum before the block starts to move. When the block of wood starts moving, the friction between it and the tabletop is called **sliding friction**.

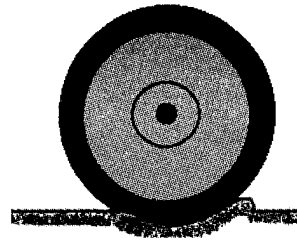
Frictional force or resistance ( $f$ ) is usually proportional to (a) the force which presses the surfaces together and (b) the "roughness of the surfaces." The frictional force is independent of area of contact. See Figure 4.5.



*Figure 4.5 The force of friction between the uniform block and the floor is equal irrespective of which side is in contact with the floor.*

There is greater frictional force between rough surfaces than smooth ones. There are cases, however, when much smoother ones have greater friction like in between sheets of flat glass and very smooth metals. If dirt or dust is removed between metal sheets, the smooth flat surfaces will actually stick to each other. This is caused by the electrostatic forces between the molecules of the sliding surfaces. This is the reason why friction could be categorized under electromagnetic force.

There is still one more type of friction that we have not discussed—**rolling friction**. As a wheel rolls on a surface, both the wheel and the surface will undergo deformations. Rolling friction is caused primarily by these deformations (Figure 4.6).



*Figure 4.6 Rolling friction is due to the deformation of the road and the wheel*

What are the advantages and disadvantages of friction? Should friction be reduced? Without friction you cannot walk or run, there would not be any structure for nothing can stick together. Friction is needed to keep parts of a structure together. You can walk because as you push the ground backward, the ground pushes back on you. Try walking on a floor with oil. Why should a runner choose a rubber shoes with greater grip than one with smooth leather sole?

Friction, however, slows down motion, of say a box being slid on the floor. The box has to be pushed all the way in order to keep it moving.

Friction needs to be increased where needed and to be decreased where undesired. Some of the ways to reduce friction is by using lubricants between moving parts or by using rollers. Between woods, make the surface smoother.

Q4.2 In the following situations should friction be increased or decreased? Explain.

- Vehicles on the road
- Sewing machine parts
- Picture frame on the wall
- Objects on a conveyor belt
- Walking
- Vehicle seat and you

## **Strong and Weak Nuclear Forces**

The other two fundamental forces in nature are the strong and weak nuclear forces that are at play within the atom. The strong nuclear force is responsible for binding the neutrons and the protons in the nucleus of an atom. The weak nuclear force is responsible for nuclear decay or nuclear radiation. The extent of these forces is within the atom only. We will not go any further in discussing these two fundamental forces.

## **Lesson 4.3 Force and Pressure**

Force and pressure when translated in Filipino sometimes mean the same thing. Are these two concepts different? Are they related to each other?

## Pressure Exerted by Solids

Two friends, Amae and Grace, are strolling by the beach. Amae is much heavier than Grace but they have the same size of feet. Who do you think creates deeper footprints on the sand? To make sure you have the right answer, do Activity 4.5.

### Activity 4.5 Pressure

#### Materials

two identical blocks of wood (about 4 cm x 4 cm x 8 cm)      soft modelling clay or flour dough  
two 1-kg mass

#### Procedure

1. Pat the modelling clay so that it will have a cross sectional area of at least 15 cm x 15 cm and a thickness of 0.5 to 1 cm.
2. Lay the identical blocks of wood with their 4 cm x 8 cm face on the clay for about three minutes. (Do not put extra pressure on the dough or clay except that which is caused by the weight of the block of wood.)
3. Remove the blocks. Compare the depression produced on the clay by the two blocks of wood.
  - a. Explain your observation.
4. Repeat steps 1 and 2 but this time put the 1-kg mass on one block. Repeat step 3.
  - a. Which block makes a deeper depression on the clay? Why do you think this is so? (*Hint*: Compare the weights of the two blocks.)
5. Repeat step 1. Lay one block with its 4 cm x 8 cm face on the clay and the other on its 4 cm x 4 cm. Put 1-kg mass on each block and let them stay for about 3 minutes. Repeat step 3.
  - a. Which block produces a deeper depression on the clay?
  - b. The depression produced on the clay is due to the pressure exerted by the block on it. What do you think are the factors that affect the pressure exerted by an object?

If you press the clay, you create a depression on it. The harder you push, the deeper is the depression created. This is also true in your activity. The push or force that a block of wood exerts on the clay is equal



to its weight. For equal areas against the clay, the block of wood with greater weight produced a greater depression on the clay. For blocks of wood with equal weights but having different surface areas against the clay, the one with less area created a deeper depression.

The above observations can be explained in terms of pressure. Pressure is defined operationally as: pressure ( $P$ ) = force ( $F$ )/area ( $A$ ), or

$$P = F/A.$$

Force (here, it is equal to the weight of the block) is expressed in newtons, N and area (the cross-sectional area of the block against the clay) is in  $m^2$ . Thus, pressure is expressed in terms of  $N/m^2$  or Pascal (Pa).

## Liquid Pressure

Water exerts pressure. If you are a diver you must have felt that the deeper you go into the water, the greater is the pressure that you experience.

Suppose you live in a four-storey building and your water supply comes from a tank. At which floor do you think would water from the faucet has the greatest pressure? weakest pressure? Why?

### Home Activity

- With a hot nail, punch 4 identical small holes along a straight line on a large plastic bottle as shown in Figure 4.7.
- Put a sticky tape on the holes to prevent water from leaking. Fill the bottle with water.
- Now remove the sticky tape. Compare the trajectory of the water streams from the different holes. Why do you think water from the different holes have different trajectories? What does this indicate?

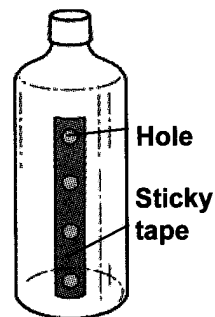


Figure 4.7 Plastic bottle with holes

The trajectory of the water is used as indicator of pressure. The longer the trajectory, the greater is the pressure at that point of the liquid column.

Water pressure at any point in a closed container is dependent on the height of the liquid above it. The other factors that affect water pressure, or any liquid, is given by the following relationship: pressure ( $P$ ) = density ( $D$ ) x acceleration due to gravity ( $g$ ) x height ( $h$ ) of the liquid, or

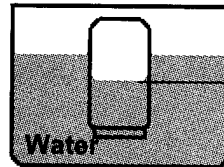
$$P = Dgh.$$

Can you now explain why water tanks are elevated? Water from a tank can only reach a maximum height along the distribution pipes up to the same level as the water in the tank.

It is not only water that exerts pressure. All liquids do.

## Air Pressure

Does air exert pressure? How would we know that air also exerts pressure?

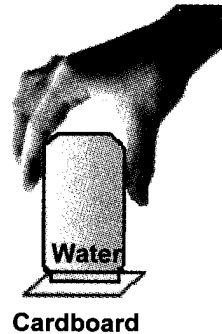


Water level inside the bottle

Figure 4.8 Inverted empty bottle submerged in water

An empty bottle is not really "empty." It has something in it. What do you think is the substance that is in an empty bottle? Fill a large transparent plastic container with tap water. Invert a small empty bottle into it as shown in Figure 4.8. Compare the water levels inside and outside of the bottle. Where is the water level lower? What does this show?

An "empty" bottle is filled with air. The fact that the water level is lower inside the bottle indicates that the air in the bottle exerts pressure on the water.



Cardboard

Figure 4.9 Inverted bottle filled with water

Do the following: (a) Fill the empty bottle with water up to the brim. (b) Cover its mouth with the piece of flat cardboard. (c) With one hand pressing the cardboard onto the mouth of the bottle, invert the bottle upside down. Be careful not to spill any water or you will let air enter the bottle. (d) When the bottle is already in its upside down position, remove your hand from the cardboard and just hold the bottom of the bottle (Figure 4.9). Does the cardboard fall? Does the water in the inverted bottle exert pressure on the cardboard? Why does the cardboard not fall?

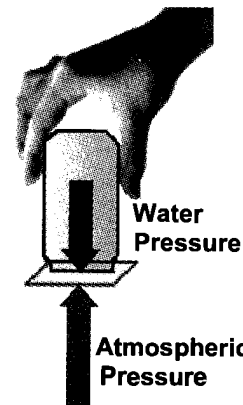


Figure 4.10 Upward atmospheric pressure is greater than the water pressure

Water exerts pressure. It therefore exerts a downward pressure on the cardboard covering the mouth of the inverted bottle. But even with that pressure the cardboard does not fall. This shows that there is a greater pressure at the bottom portion of the cardboard. Such a pressure is exerted by the air acting on all sides outside of the bottle. The air pressure on the cardboard is

upward thereby counteracting the downward pressure of the water inside the bottle (Figure 4.10).

In the same manner that the liquid's pressure at one level depends on the height of the liquid above so does the atmosphere. At sea level where the air column extends up to the uppermost layer of the atmosphere, the pressure is  $101\,325\text{ N/m}^2$ . This is equivalent to the pressure of about 103 sacks of rice stacked one on top of the other. (Each sack is assumed to have a mass of 50 kg and its surface area against the ground to be  $0.5\text{ m}^2$ ). Atmospheric pressure decreases as the distance from the ground increases.

## Lesson 4.4 Force and Motion

One effect of force on an object that is free to move is a change in its motion, either a change in its speed or direction of motion or both.

Consider two identical toy cars, A and B, which are side-by-side on a long table or on the floor. (You can do this at home.) Push the cars at the same time but exerting a greater force on one. Which of the two will go farther? Which moved faster? The one which moved faster has greater speed. In elementary school science, you operationally defined average speed as: average speed ( $v_{av}$ ) = distance travelled ( $d$ )/time ( $t$ ), or

$$v_{av} = d/t.$$

Distance  $d$  is in metres (m), time  $t$  in seconds (s), so speed  $v$  is in m/s. Speed, however, is commonly expressed in kilometre/hour (km/h or kph) when talking about vehicle motion.

Suppose that Car A in the situation described above traveled a distance of 3 m in 2 s while Car B a distance of 1.5 m in 2 s? What are their respective average speeds? Using the relationship given above, Car A had an average speed of 1.5 m/s while B had 0.75 m/s. Car A had greater speed or it moved faster than Car B.

Q4.3 Compare the running speeds of Amae and Grace. Amae travels a distance of 100 m in 40 s while Grace covers a distance of 150 m in 60 s.

The speedometer of a vehicle is an instrument that measures speed, not the average speed but the speed of the vehicle at that specific instant.

Speed and velocity are two different quantities. **Speed** describes how fast an object is moving while **velocity** describes both how fast an object is moving and in what direction it is going.

Q4.4 Figure 4.11 shows a diagram of two cars traveling with equal speeds but in different directions. Do they have equal velocities? Explain your answer.

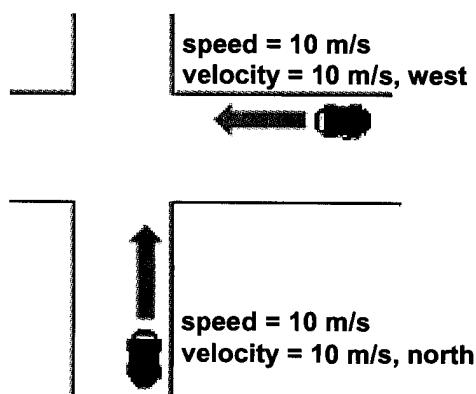


Figure 4.11 Cars having equal speed but traveling in different directions

## Newton's Laws of Motion

The first law is known as law of inertia. The law states that an object at rest will stay at rest or an object in motion will stay in motion unless acted on by an unbalanced force. If a body at rest moves or a moving body changes its speed or direction of motion, then for sure there is unbalanced force acting on the body. A body at rest will move in the direction of that force.

Newton's first law is very evident in our daily experiences. When you are in a moving vehicle, especially if it is moving fast, you lean forward when it suddenly stops. This is because you are initially in motion and your tendency is to keep on moving. So, when your vehicle suddenly stops, you still move forward. This is quite dangerous if you are in the front seat of a fast-moving car and it makes a sudden stop to avoid colliding with a rigid body. You will be thrown out of the windshield if you are not using a seatbelt.

You must have also experienced that if the vehicle moves forward abruptly, you lean backward. This is because you are initially in a state of rest so your tendency is to stay that way. As the vehicle negotiates a curve, you sway outward. This is because your inertia makes you keep on moving in a straight line.

Newton's second law relates the mass of the object to the change in its velocity for a given applied force. Recall that force is needed to move an object initially at rest. If the object is already moving, the force applied can make it move faster or slower or change its direction. The force can also make it stop depending on the direction of the force applied relative to the motion of the object. In any case, the velocity of the object is changed when a force acts on it.

The change in the velocity of an object in a given time depends on two factors: applied force and the mass of the object. This means that if the applied force on an object is small, its change in velocity in a given time is also small. If the applied force on an object is large, then its change in velocity in a given unit of time is also large.

Suppose two objects of unequal masses experience equal force. Newton's second law says that the object with less mass has a greater change in velocity in a given period of time than the one with greater mass. It also means that greater force is needed to slow down a heavy object than a lighter one within the same period of time. Also, with the same force, a lighter object will increase its speed faster than a heavier one.

**Q4.5** Suppose you are about to cross along a pedestrian lane. The stoplight has just signalled that you can already cross the street. You see a car on your left that is slowing down as it approaches the pedestrian lane. Are you going to cross? What if you see a heavy truck moving with the same speed as the car, are you going to do the same thing? Why?

Newton's third law is also very obvious in our daily life. It states that "For every action, there is an equal and opposite reaction." Some examples of the third law's force pairs include the following: (a) You can walk because of the forward force that the ground or floor exerts on your feet (Figure 4.12); (b) A swimmer can easily reverse direction at the end of a swimming pool by exerting force on the pool's wall and the wall exerts an opposite force on the swimmer; (c) Your hands hurt if you hit a wall because the wall exerts an opposite force on your hand. The greater your force the greater is the force that the wall exerts on you; and (d) A balloon moves forward as the air from it is released. The balloon exerts a rearward force on the air while the air exerts a forward force on it.

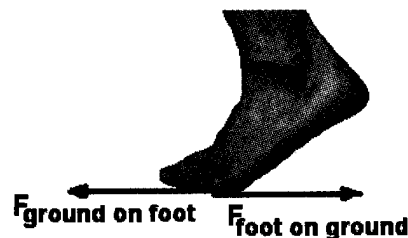


Figure 4.12 Action-reaction force pair

## Lesson 4.5 Work

What does work mean to you? What activities do you associate with work? Some of your chores, no matter how hard you do it may not be considered work in science. On the other hand, some activities, which are considered play may actually be work in science.

Suppose you do the following. In which situation/s have you done work? (a) Carry a 20-kg box on your head while walking horizontally; (b) Pick up a pencil on the floor and place it on a table; (c) Carry your heavy bag while standing at one corner of a waiting shed for 20 minutes; and (d) Push with all your might against a rigid wall. You surely had a hard time accomplishing (a), (c), and (d). But you have not done work. Only in (b) that you have done work even if it is the easiest thing to do.

In science, work ( $W$ ) is done only when the object on which force ( $F$ ) is applied moves through a certain distance ( $d$ ). If the object does not move, no matter how large the applied force is, then there is no work done on the object.

In symbols, work is expressed as

$$W = F \times d.$$

In SI units, force  $F$  is in newton (N), distance  $d$  is in metre (m), and work  $W$  is in joule (J).

In order for the above equation to hold, the following condition should be observed: the direction of the force applied should be the same as the direction of the object's motion as shown in Figure 4.13a. If they are not, then only the component of the force in the direction of the motion should be considered. To understand this, study Figure 4.13b. Note that the direction of motion is rightward along the horizontal. The force is also rightward but it also has an upward component. In this case, since the object has to be moved horizontally, only the horizontal component of the force is effective in doing the work. See Figure 4.13.

When the force applied is perpendicular to the direction of motion as shown in Figure 4.13c, the force does no work. Consider a man carrying a sack of rice on his shoulders and walking on level ground. The man applied an upward force on the sack of rice but the sack of rice moves horizontally. From the above definition of work, no work is done.

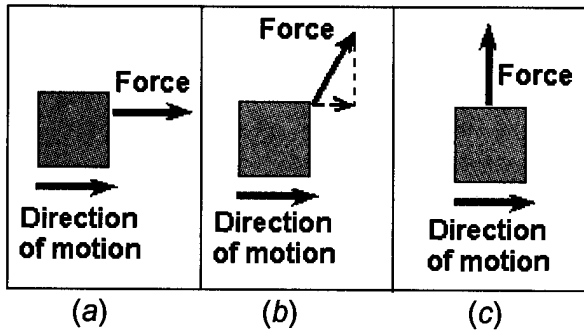


Figure 4.13 Work done by force on an object depends on its relative direction to the direction of motion.

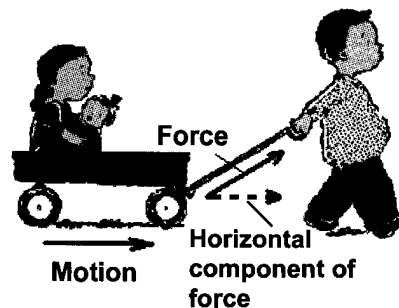


Figure 4.14 Only the horizontal component of the force does work

Carrying anything, even a heavy load, where no distance is travelled along the direction of the force makes work done equal to zero. You can push a wall with all your might but work is still zero because the wall is not moved.

Now go back to the four situations, a to d, at the beginning of this lesson. Can you now see why only in (b), picking a pencil on the floor and

placing it on a tabletop, is there work done? This is because both the force exerted on the pencil and its direction of motion is upward.

To summarize our discussion on the definition of work, consider Figure 4.13 again. In all three cases, the amount of force exerted is equal. (The length of the "force" arrow represents the amount of force). However, since the force in each case is oriented in different directions, the work done are not equal.

In (c), there is no work done or  $W = 0$  since there is no component of the force along the direction of motion. In (a) and (b) the amount of force (solid arrows) are equal but the component of the force along the direction of motion in (a) is greater than in (b). The component of the force in (b) is shown by the dashed arrow. Assuming that the distance moved are equal in (a) and (b), then the work done in (a) is greater than in (b).

Q4.6 Indicate the amount of work done in each case. (a) Meg, weighing 400 N, but carrying no load at all climbs up the stairs to the next floor 5 m above; (b) Paul, weighing 700 N with a 10-kg baggage on his shoulder, walks through a horizontal distance of 10 m.

## Work and Machines

Suppose you want your house to have a new look. The tree in front of the house needs to be trimmed, logs nearby have to be moved. Inside the house, pieces of furniture have to be rearranged, new things have to be displayed, and others have to be cleaned. In doing these, what are you going to use to accomplish your tasks easily? Of course you can use machines. Why can machines make your work easier and faster?

A machine helps us do work because it can (a) multiply force, (b) multiply distance, or (c) change the direction of force. Which of these simple machines: lever, pulley, inclined plane, screw, wedge, and wheel and axle can multiply force or distance or change the direction of the force?

The advantage of using a machine can be seen in its mechanical advantage ( $MA$ ), which can be expressed in three ways. But first, recall some terms. See Figure 4.15. The  $MA$  can be calculated in three ways depending on what is known:

(a)  $MA = \text{resistance force/effort force}$ , or  $MA = R/E$

(b)  $MA = \text{effort arm/resistance arm}$ , or  $MA = e/r$

(c)  $MA = \text{distance the effort moves/distance the resistance moves}$ , or  $MA = d_e/d_r$ .

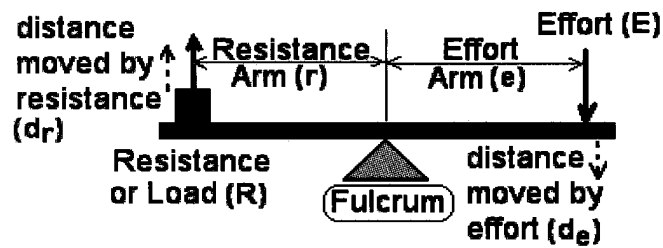


Figure 4.15 Parts of a machine

To help you calculate the *MA* of some machines, do the following activity.

### Activity 4.6 Machines

#### Materials

- rigid cylinder or triangular object to serve as fulcrum
- 30 cm flat and stiff wooden or metal ruler or uniform rod with markings at every cm to serve as lever
- 12 coins of the same kind (say P1.00 coins)

#### Procedure

1. Check if your ruler balances at its 15-cm mark on the cylinder. If it is not balanced make some adjustments by putting some small weights at the side which is lighter.



2. Have the fulcrum at the 8-cm mark as shown. Place 3 coins, one on top of the other with their centers at the 2-cm mark. This is the *resistance* or *load* of the lever.
3. Use 1 coin for the *effort*. Find its position until the lever is balanced. Determine the effort and resistance arms. These are measured from the fulcrum. Also note the effort force. Prepare a data table similar to the one below.

Trial	Fulcrum Position (cm)	Load or Resistance (coins)	Resistance Arm (cm)	Effort (coins)	Effort Arm (cm)	Mechanical Advantage	
						R/E	e/r
1	8	3	6	1			
2	15	3	13	3			
3	22	3	20				



4. Press the ruler where the effort is, then remove the "effort" coin. Compare the distance moved by the resistance and the effort.
  - a. Which is longer, the distance moved by the effort or by the resistance?
5. Retain the 3-coin load at the 2-cm mark. Adjust the fulcrum to be at the 15-cm mark. Use 3 coins for the effort. Determine the effort and resistance arms.
6. Repeat step 4.
  - b. Compare the distance moved by the effort and the resistance?
  - c. If you exert a downward effort force, what is the direction of the force exerted by the lever on the load or resistance?
7. Repeat step 5 but move the fulcrum to the 22-cm mark. Now you can choose the number of coins for the effort and determine where it/they should be placed to balance the lever.
8. Repeat step 4.
  - d. Compare the distance moved by the effort and the resistance?
9. Calculate the mechanical advantage using the resistance and effort forces, and the effort and resistance arms.
  - e. When is the MA greater than 1?
  - f. What is the advantage of using a machine with MA greater than 1?
  - g. When is the MA equal to 1?
  - h. What is the advantage of using a machine with MA equal to 1? (Compare the directions of the resistance and effort forces.)
  - i. When is the MA less than 1?
  - j. What is the advantage of using a machine with MA less than 1? (Hint: Compare the distance moved by the resistance and the effort.)
  - k. With a line, match the information in column 1 with that in column 2:

Mechanical Advantage	Advantage of Using the Machine
MA > 1 <input type="checkbox"/>	<input type="checkbox"/> Multiplies distance
MA = 1 <input type="checkbox"/>	<input type="checkbox"/> Multiplies force
MA < 1 <input type="checkbox"/>	<input type="checkbox"/> Changes the direction of force

When the resistance force or the load is greater than the force needed to move it (that is, effort force is less), the mechanical advantage is greater than 1. The advantage of using such machine is in multiplying

force. Examples of machines that multiply force are the inclined plane, wedge, screw, and wheel and axle. In a wheel and axle, the effort is exerted at the wheel as found in a doorknob and steering wheel. In the pulley system, the load is greater than the effort force while in levers, the resistance arm is less than the effort arm. Examples of such levers are bottle opener, handle of a jackscrew, wheelbarrow, wrench, hammer, and all second class levers (Figure 4.16b).

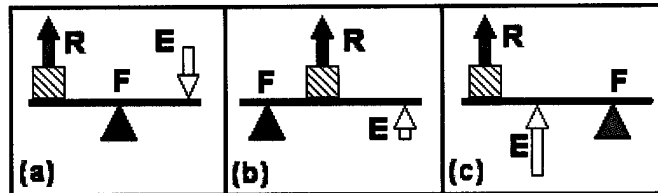


Figure 4.16 (a) First class, (b) second class, and (c) third class levers

When the mechanical advantage of a machine is equal to 1, the effort force is equal to the resistance force. Nothing is gained in terms of force or even distance. However, note that the direction of the resistance and effort forces are in opposite direction. Hence, the advantage of using this machine is in changing the direction of the force. An example is a single fixed pulley attached at the top of a flagpole.

A machine with mechanical advantage of less than 1 multiplies distance. This means that the load is moved over a greater distance than the effort. Examples of levers with resistance arms greater than their effort arms are broom, shovel, fishing pole, baseball bat, tongs, and all third class levers (Figure 4.16c).

## Lesson 4.6 Aspects of Energy

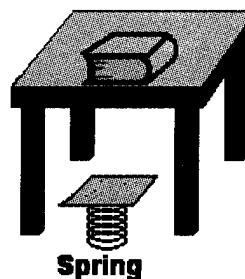
When an object can do work, it has energy. The greater work it can do the greater is its energy. It is because of this that energy is usually defined as the capacity to do work. But this is just half the truth about energy. Aside from its capacity to do work, it also has the capacity to make other things hotter. So it is better to say that an object has energy if it can do work or can make other things hotter.

### Forms of Energy

Energy comes in different forms: mechanical, chemical, electrical, radiant, internal, nuclear, and sound.

**Mechanical energy** is the form of energy that an object has when it is moving, is deformed or is at a higher position relative to a certain level. Energy due to motion is called **kinetic energy**. Energy due to position

and configuration is called **potential energy**. It is wrong to say that potential energy is the energy possessed by a body at rest. A book on a table has potential energy not because it is at rest but because it is at a higher position relative to the floor. If it falls from that height and a spring happens to be on the floor, then the book can do work on the spring if it falls on it. A deformed (compressed or stretched) spring has also potential energy. Mechanical energy is the sum of the kinetic and potential energies of the object.



*Figure 4.17 A book on a table has potential energy because it is at a higher position relative to the floor*

**Chemical (potential) energy** is the form of energy which you always have. Your body systems cannot function without it. Energy stored in your fat, in the food you eat, and in fossil fuels are examples of chemical energy. This is the energy associated with the composition or structure of the particles of a material. Changing these would change the chemical energy of the material. When a material is burned as when food and oxygen react, energy is always released. Chemical energy from fossil fuels is released when these are burned. This is what keeps the vehicle's engine running.

**Electrical energy** is the form of energy that you always use at home. Most people depend so much on this energy that much of their activities are discontinued when there are brownouts. This energy is brought about by the motion or position of electric charges. Electrical energy may come from different sources. Dry cells and batteries provide the electrical energy for your cell phones, small radios, and digital clocks. But your electrical energy needs at home come from big electric power plants and brought to you through long transmission and distribution lines.

**Sound energy** is the form of energy associated with the vibration or disturbance of matter. Sound waves require some kinds of materials to travel through. They cannot move through a vacuum.

**Radiant energy** is the form of energy that enables you to see the things around you, communicate with relatives and friends from afar. This includes radio waves, X-rays, infrared and UV rays, and visible light like those from the sun and hot materials.

**Internal energy** is the energy in matter that accounts for the motion and interaction among its molecules. Particles of matter are in constant motion because they have kinetic energy. Particles also interact with each other so that they too have potential energy. The sum of the particles' kinetic and potential energy is its internal energy. The temperature of matter is actually dependent on straight-line movement of

the molecules. Some use internal and thermal energy interchangeably. Others however, confine the word thermal energy when concerned only with the internal energy that relates to temperature. Heat should not be interchanged with internal or thermal energy. Although heat is taken as energy in transit, it is not a form of energy but is a way of transferring energy.

**Nuclear energy** is attributed to the composition of the nucleus. This can be released when the nuclear composition of atoms changes as in nuclear fusion and fission and in nuclear decay.

Q4.7 Write the form of energy that can be harnessed from: (a) dry cell, (b) wind, (c) sun, (d) falling water, (e) big unstable atom, (f) steam, (g) stretched bow, and (h) vibrating string.

## Energy Transformation

Have you taken a ride in a roller coaster? Where do the cars or coasters usually begin? If it has a loop-d-loop part, how will you compare the maximum height of the loop to the height where the car begins? Why do you think the car has to begin from that point? You can answer these questions after doing Activity 4.7.

### Activity 4.7 Kinetic and Potential Energy

#### Materials

small block of wood  
size D dry cell and short PVC pipe or any two cylinders having the same size but different masses  
plank (about 50 cm long and 10 cm wide)

#### Procedure

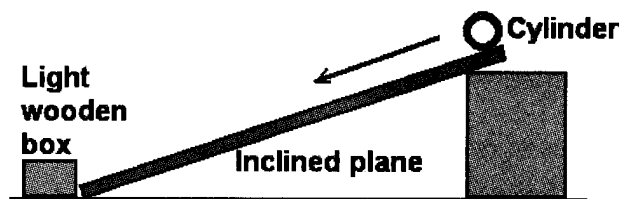
##### Part A: Kinetic Energy

1. On a flat surface (tabletop or floor), roll the dry cell toward the small block of wood. Record the distance moved by the block.
  - a. Is the rolling cylinder able to do work on the small block of wood? Why do you say so?
  - b. What form of energy does a rolling cylinder have?
2. Repeat step 1 but give the dry cell less speed. Compare the distance moved by the block of wood in steps 1 and 2.
  - c. Compare the work done by the rolling dry cell having different speeds. Why do you say so?

- d. Compare the kinetic energy of the rolling dry cell in steps 1 and 2. What contributed to their difference?
3. Repeat step 1 with the short PVC pipe. Make sure that its speed is equal to the dry cell's speed in step 1. Compare the distance moved by the block of wood in steps 1 and 3.
    - e. Compare the masses of the PVC pipe and the dry cell.
    - f. Now compare their kinetic energy. Why do you say so? What contributed to their difference?
    - g. What are the factors that affect the amount of kinetic energy of objects?

**Part B: Potential Energy**

4. Raise one end of the plank by 12 cm to have an inclined plane as shown.
5. Position the block of wood at the foot of the inclined plane.



6. Aim and release the dry cell from the top of the inclined plane onto the block of wood. Note the distance traveled by the block.
  - h. What form of energy does the cylinder have while at the topmost part of the inclined plane?
7. Repeat step 6, but this time use the PVC cylinder.
  - i. Compare the amount of work done by the cylinders in steps 6 and 7.
  - j. Compare the potential energy of the cylinders in steps 6 and 7. Why do you say so? What caused the difference in their potential energies?
8. Raise the higher end of the inclined plane by another 12 cm to have a total of 24 cm and repeat step 4.
  - k. Compare the amount of work done by the dry cell in steps 6 and 8.
  - l. Compare the potential energy of the dry cell in steps 6 and 8. What caused their difference?

### Part C: Kinetic and Potential Energy

9. Decrease the slope of the inclined plane. Roll a cylinder from the top of the inclined plane. Observe the speed of the cylinder as it rolls down. Does it go faster or slower or maintain its speed?
- m. What happens to the speed of the cylinder as it rolls down? What does this show of the kinetic energy of the cylinder?
  - n. What happens to the height of the cylinder as it rolls down? What does that show of its potential energy?
  - o. Summarize what happens to the cylinder's potential and kinetic energy as it rolls down the inclined plane.

A rolling cylinder has kinetic energy; hence it is able to do work. It can do greater work when it has greater kinetic energy. The amount of work done by a moving object can be a measure of the kinetic energy it has. An object has greater kinetic energy if it has a greater speed. But if there are two objects having different masses, even if they have equal speeds, the one with greater mass has greater kinetic energy. Kinetic energy then depends on two factors: mass and speed of the object. The higher these two are, the greater is the kinetic energy of the object. In fact, the relationship that these three quantities have is given by: kinetic energy =  $\frac{1}{2}$  mass  $\times$  speed<sup>2</sup>, or

$$KE = \frac{1}{2} mv^2.$$

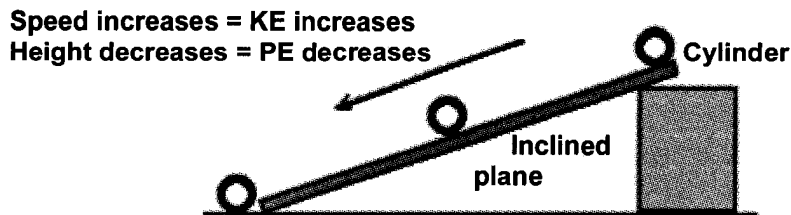
Mass  $m$  is expressed in kilograms (kg), speed  $v$  is in metres/second (m/s), so that kinetic energy  $KE$  is in  $\text{kg} \cdot (\text{m/s})^2$ . Kinetic energy, therefore is  $\text{kg} \cdot (\text{m/s})^2 = (\text{kg} \cdot \text{m/s}^2) \cdot \text{m}$  or  $\text{N} \cdot \text{m} = \text{joules (J)}$ .

An object that is raised has potential energy. The amount of potential energy that an object has can be seen from the amount of work it can do when released. The higher an object is raised the greater is its potential energy. However, if there are two objects having different masses, although placed at the same height, the one with greater mass has greater potential energy. The relationship of these three quantities is given by: potential energy = mass  $\times$  acceleration due to gravity  $\times$  height, or

$$PE = mgh.$$

Take note that acceleration due to gravity  $g$  is the same for all objects. For now, we are going to use the value  $10 \text{ m/s}^2$  at the surface of Earth. Let us now consider the units: mass  $m$  is in kg and height  $h$  is in metres (m). So potential energy  $PE$  is in  $[\text{kg} \cdot (\text{m/s}^2)] \cdot \text{m}$  or joules (J).

The speed of a cylinder increases as it rolls down the inclined plane, thus, its kinetic energy increases. At the same time, its height decreases so its potential energy decreases. Figure 4.18 illustrates what happens to the kinetic and potential energy of the cylinder as it rolls down the inclined plane.



*Figure 4.18 The kinetic energy of the cylinder increases as it goes down the inclined plane but its potential energy decreases.*

A decrease in the cylinder's potential energy is compensated by an increase in its kinetic energy.

Energy transformation (or changing to other forms) is not only confined to mechanical energy, say from potential to kinetic energy, but is also true for the other forms of energy. Other forms of energy can be transformed to another form of energy or a combination of two or more forms. Consider the following examples: (a) Chemical energy in dry cells of a flashlight is transformed to electrical energy in the circuit then to light in the flashlight bulb. Thermal energy is also produced in every transformation; (b) Chemical energy stored in food is stored as chemical energy in our body, which is later transformed to kinetic energy as we perform our activities and also to thermal energy as we perspire; (c) When we talk on the phone, our voice is changed to electrical energy. The phone at the other end changes electrical energy into sound energy and along the way thermal energy is also produced; (d) A toaster changes electrical energy into thermal energy; and (e) An electric fan transforms electrical to mechanical energy. Touch the motor casing of the electric fan just after use and you will feel that it is warm showing that thermal energy is also produced.

You learned in this section an important aspect of energy, that is, energy can be transformed from one form to another.

## Conservation of Mechanical Energy

Is mechanical energy (ME) conserved in a cylinder that rolls on an inclined plane? Have another inclined plane similar to the one you used in Activity 4.7. Arrange them as shown in Figure 4.19. Release the cylinder on one side and observe how high it will roll to the other side. You will observe that the cylinder will not roll to the other side of the ramp at a height similar to its height when it was released.

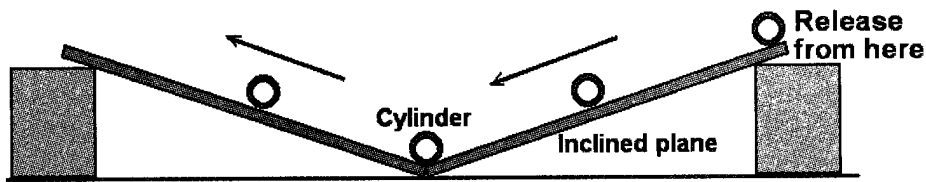


Figure 4.19 A cylinder going up to the other side of the ramp does not attain the same height compared to its height when it was released.

Since the cylinder attains a lower height on the other side of the ramp, we can say that its ME has decreased. This loss of its ME is caused by the friction between the surface of the inclined plane and the cylinder. If the cylinder's ME were conserved, then the cylinder could have rolled to a height on the other side of the ramp similar to its height when it was released. By using a setup with minimal or negligible friction such as a pendulum, you will observe that the bob will swing to a height equal to its original height. So when friction is absent, mechanical energy is conserved.

Figure 4.20 shows the energy transformation that happens in a pendulum bob. At its maximum height (Position 1), while the bob is at rest, all its ME is in the form of PE (PE is at its maximum while its KE is zero or at its minimum). As the bob goes down, its PE decreases while its KE increases attaining its maximum value at its lowest position (Position 3) while PE becomes zero. Due to inertia, the bob goes beyond its lowest position. Its PE increases (because it is going higher) but its KE decreases (since it slows down until it eventually stops momentarily at the highest position, Position 5). At Position 5, all its energy is again in the form of PE or its PE is at its maximum and KE is zero. Since the bob attains its original height at Position 5 its PE at Positions 1 and 5 are equal.

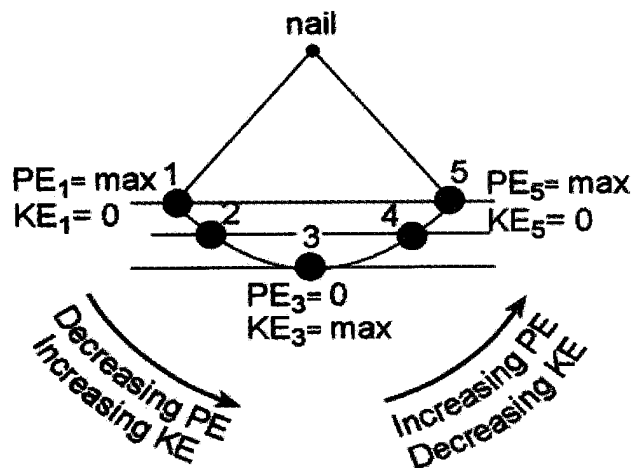


Figure 4.20 The mechanical energy of the pendulum bob changes between potential and kinetic energy but the total of the two remains the same at any point.



KE at its lowest position is equal to its PE at its highest position. Between its lowest and highest position, the bob's energy is a combination of PE and KE, the amount of each depends on the height (or speed) of the bob. At any position, the total ME of the bob is constant. As energy is transformed, energy is conserved. In equation form:

Mechanical Energy = Potential Energy + Kinetic Energy, or

$$ME = PE + KE = \text{constant.}$$

Mechanical energy conservation, however, does not depend on path. As long as there is no friction, ME is conserved.

Friction at the point of suspension of the pendulum and friction due to air resistance are negligible. Friction, however, is not negligible if an object moves along a track, as in a roller coaster. So a coaster must come from the highest position in the track. Mechanical engineers have to be accurate in calculating the energy lost due to friction so that the coaster or car can go over other high positions in the track especially when it has a loop-d-loop part.

## Conservation of Energy

Consider a bouncing ball (Figure 4.21). The ball bounces for several times but eventually stops and rests on the floor. At the point of release (Position 1), the ball has its maximum PE and zero KE. As the ball is about to touch the ground (Position 2), it has attained its maximum speed, therefore its KE is at its maximum and its PE is about zero. Its entire PE at Position 1 has been transformed to KE at Position 2.

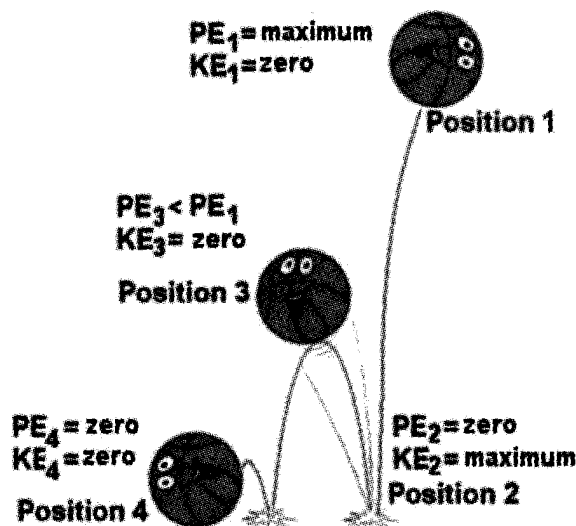


Figure 4.21 The mechanical energy of a bouncing ball decreases at every bounce.

After the first bounce, however, the ball cannot attain its original height (compare Positions 1 and 3), hence its PE has decreased. Since it momentarily stops at Position 3, its KE is zero. Its total mechanical energy then at Position 3 is less than at Position 1. Mechanical energy is therefore not conserved. When the ball eventually stops on the ground (Position 4) all its PE and KE are lost. It no longer has any mechanical energy. Where has all the mechanical energy in Position 1 gone?

Suppose you hammer a metal and compare the temperature of the hammer and the metal after pounding it several times. You will feel that both the hammer and the metal become hotter. Where does the additional internal energy of the two come from since there is no heat source nearby? The gain in their internal energy comes from the lost mechanical energy of the hammer each time it is raised. In the same manner, the lost mechanical energy of the bouncing ball is transformed to internal energy of the ball and the ground, and some of it to sound energy.

The mechanical energy of the ball is not lost and cannot be traced; it is only transformed into another form. Conservation of energy then is not confined to mechanical energy but in the totality of energy, considering all forms.

Consider the energy transformation in an electric fan. You would have noticed that an electric fan or any machine or device that is used for some time becomes warmer. Figure 4.22 shows that the initial amount of energy (electrical energy) is equal to the final amount of energy (thermal energy of the motor which is later dissipated to the environment + kinetic energy of the rotating blades).

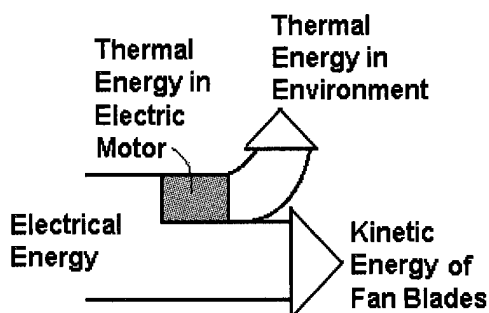


Figure 4.22 Energy transformation in an electric fan

When energy is transformed from one form to another, energy is always conserved, that is, the total amount of energy is constant.

While energy is always conserved, the final amount of useful energy is always less. Thus, there is the need to conserve the useful forms of energy. Mechanical and electrical energies are the most useful forms of energy because it is possible to convert them (almost) totally to any other energy form. Internal energy (especially at low temperature) is considered as the energy form with least value since this can only be transformed to a useful form of energy (mechanical energy) to a limited extent.

## Energy Transfer

You need energy to do your activities. Where does your energy come from? Of course it comes from the food you eat. Is the energy in the food on a table useful? When is it useful? When do charcoal and gasoline become useful? Can these be useful if they are just in their containers?

The energy that an energy source has is not useful if it is left within the energy source. Energy must have to be transferred from one body (the source) to the body which uses it. When energy is transferred, it is usually transformed. What are the ways of transferring energy?

### Work

Take two identical coins, A and B, at rest and separated by about 10 cm on a tabletop. Push A toward B. Observe what happens to the two coins before and after they collide. What happens to the PE of the two coins before and after collision? What happens to the KE of the two coins during collision? Has there been a transfer of energy from one coin to the other? Why do you say so? During collision does A exert force on B through a distance? Why do you say so? Has A done work on B? Explain. Relate doing work and energy transfer.

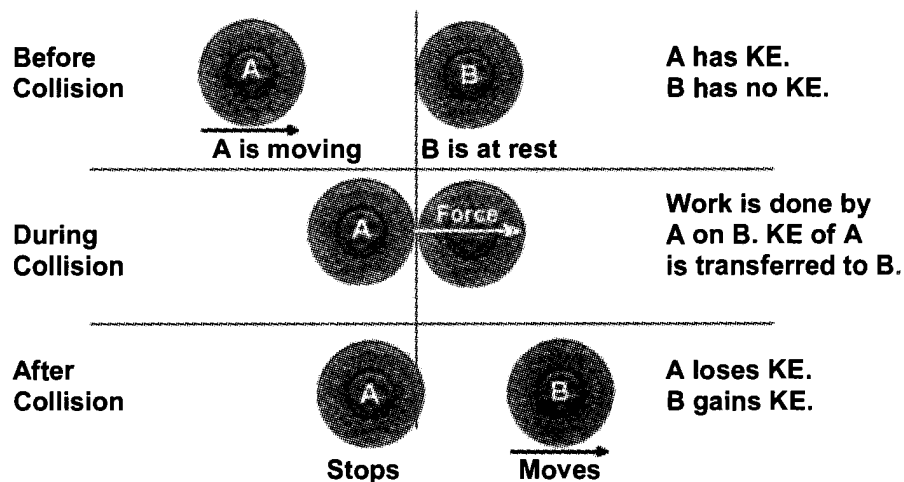


Figure 4.23 Energy is transferred from Coin A to Coin B through work.

The two coins, irrespective of which is moving, have equal PE since they have equal mass and are at the same height. Before collision, A has KE while B does not have. After collision, A lost its KE while B gains KE. There could have been a transfer of KE from A to B.

The two coins, irrespective of which is moving, have equal PE since they have equal mass and are at the same height. Before collision, A has KE while B does not have. After collision, A lost its KE while B gains KE. There could have been a transfer of KE from A to B.

During collision, A bumps B, that is, it exerts a force on B through a distance. It does work in doing so (Figure 4.23). B moves while A stops. A loses its KE and transfers it to B through the work it does. This demonstrates that work is a way of transferring energy from one object to another.

Q4.8 Explain how energy is transferred from a person to a bow and arrow, and finally to the arrow that is released to the air. Use the word work in your explanation.

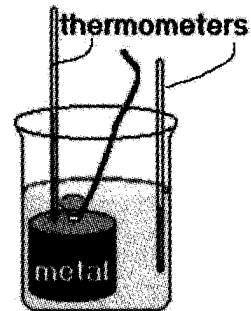
## Heat

Consider a pot of water on a hot plate. How is the thermal energy of the hot plate transferred to the pot of water? Do the following simple activity.

### Activity 4.8 Heat

#### Materials

metal ball or cylinder      boiling water  
transparent container      2 thermometers



#### Procedure

1. Half-fill your glass container with tap water. Measure the temperature of the tap water.
2. Immerse the metal object into the boiling water. Let it stay there for at least 2 minutes. Measure the temperature of the hot water-metal system before transferring the metal object to the container with tap water. This is the initial temperature of the metal object.
3. Immediately transfer the metal object into the glass of tap water.
4. Position 1 thermometer on top of the metal object and the other away from it as shown. Note the temperature readings on the two thermometers every minute for about 3 minutes.
  - a. What form of energy can a hot object transfer to other objects? When can this happen?
  - b. Compare the internal or thermal energy of the metal object before and after submerging it into the tap water? Why do you say so?
  - c. Compare the internal or thermal energy of the tap water before and after submerging the metal object into it. Explain.
  - d. Is there a transfer of energy in this activity? If yes, (a) which object transferred its energy and where did its energy go? (b) Why do you think energy is transferred?

A change in the temperature of an object indicates that there is a change in its internal or thermal energy. If its temperature decreases its internal or thermal energy decreases. If its temperature increases, its internal or thermal energy increases.

Objects having different temperatures when made to touch each other will eventually have their temperatures equal. The hot object becomes cooler and the colder object becomes warmer. This shows that the hotter object loses internal or thermal energy while the colder object gains internal or thermal energy. Energy is transferred from the hotter to the colder object through heat. Heat is also known as energy in transit. Once the energy is already in the colder object, the energy transferred is no longer called heat but becomes a part of the internal energy of the colder object. Remember this: heat is not a form of energy but a means of transferring energy like work.

To summarize, energy is transferred through work and heat. Heat is the energy transfer that happens because of temperature difference. Figure 4.24 shows diagrams of sample energy transformation and transfer. Note the roles of work and heat—both are means of transferring energy.

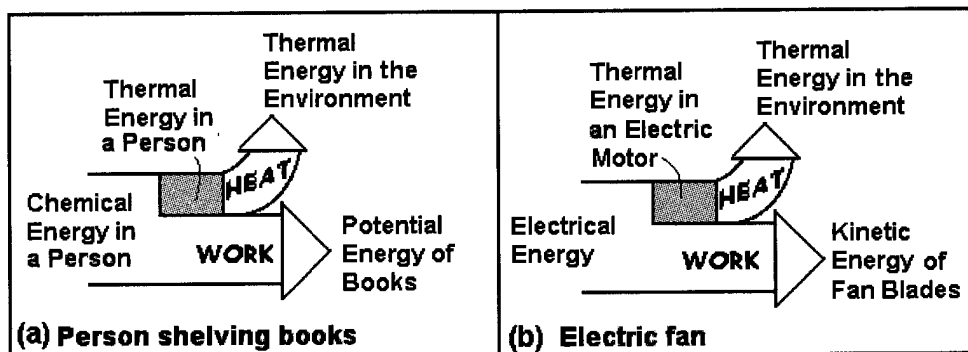


Figure 4.24 Roles of work and heat in energy transfer

In any energy transformation and transfer, the thermal energy transferred to the environment is wasted. This is why we need to conserve the useful forms of energy.

## Lesson 4.7 Methods of Heating

There are three methods of heating or transferring energy through heat: conduction, convection, and radiation. How is one distinguished from the others?

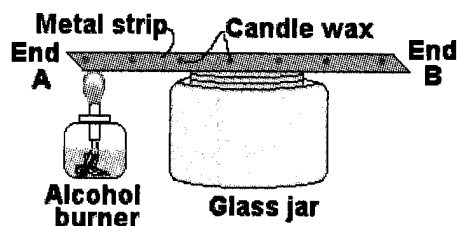
## Conduction

Before anything else do Activity 4.10.

### Activity 4.9 Conduction

#### Materials

20 cm long metal strip  
wide-mouthed glass jar or  
wooden blocks  
match  
candle  
alcohol lamp



#### Procedure

1. Put drops of melted wax from a lighted candle, about 3 cm apart, on the metal strip as shown.
2. Lay the metal strip horizontally on the jar or wooden support with the wax balls on top.
3. Hold the alcohol burner such that its flame is below end A of the metal strip. Observe the order in which the wax balls melt.
  - a. What does your observation show on the manner in which energy is transferred?
  - b. Describe how conduction happens.

The candle wax nearest the flame melted ahead and the one farthest melted last. The activity shows that heating of the metal strip is not at one time but starts from the heated end. This shows that heat conduction starts from the hot end toward the cold end.

**Conduction** is energy transfer by means of particle disturbance within a material. Suppose that the particles of the metal strip you used in your activity can be seen. At the heated end (End A), the particles move more vigorously (solid circles in Figure 4.25).

As they move about they collide with the slower particles (hollow circles in the figure) making them move as fast as they do. As such, energy is passed on toward the colder end (End B). As End A is continuously being heated, energy is passed on from the particle at that end toward End B by particle collision. As time goes on particles at End B would be moving as fast as those at End A. By this time if you happen to touch End B, it would feel hot.

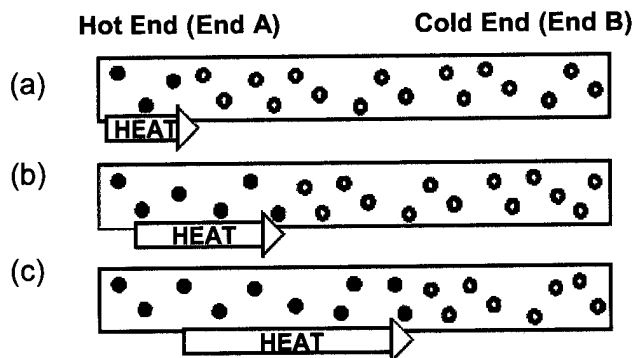


Figure 4.25 Solid circles represent fast-moving particles while hollow circles represent slow-moving particles

Q4.9 Why are cooking pans made of metals while their handles are made of rubber or wood?

## Convection

How is heat transferred through convection? Get the following materials: a large jar with cold water, a small bottle with a two-holed cover (each hole with short improvised tube as in Figure 4.26), stove, cooking pan, and dye to color water (preferably red, green, or violet). Heat a small amount of colored water to near boiling. Pour colored hot water into the small bottle or vial. Cover the small bottle with its holed cover. Carefully lower the small bottle into the jar with cold water. Describe the movement of the colored water from the small bottle into the cold water. How does the hot colored water from the small bottle move within the cold water? Explain why the hot water moves the way it does. (Hint: Think of the density of hot and cold water.)

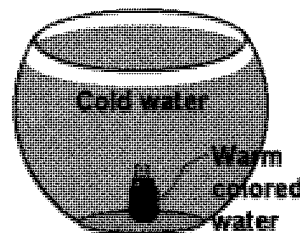


Figure 4.26  
Convection jar

Do the following activity to find out. It is similar to your home activity.

### Activity 4.10 Convection

#### Materials

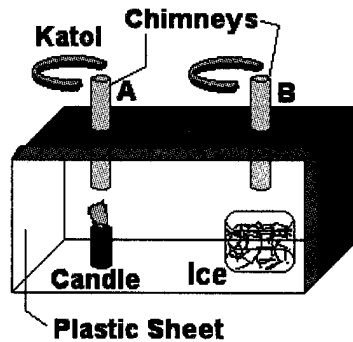
convection box      match      smoke source (e.g., *kator*)

#### Procedure

1. Light a short candle and put it inside the convection box under Chimney A and put ice under Chimney B. Put a smoke source over

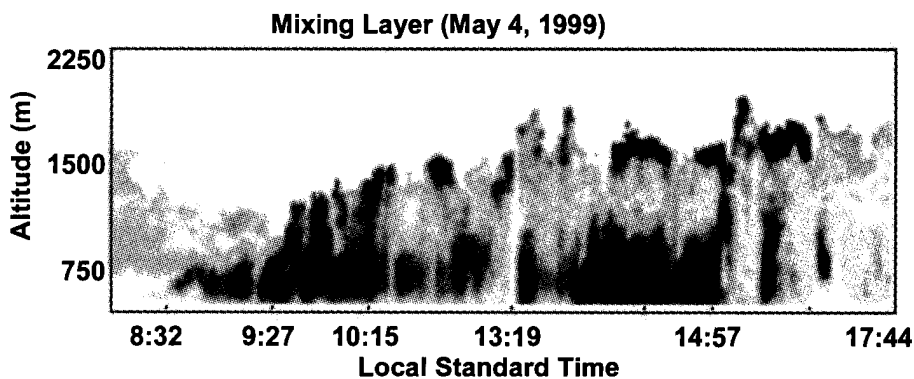
each chimney. See the figure next page.

- Draw the direction of the smoke over Chimney A on a sheet of paper.
- Draw the direction of smoke in Chimney B.
- What is the difference between the air in Chimney A and that in Chimney B?
- How does air move within the box?
- Explain why it moves that way.



Convection happens when a portion of the fluid (gas or liquid) is heated. A fluid expands when heated; hence, it becomes less dense than its colder environment. As such it rises. On the other hand, the colder and denser part of the fluid sinks. The upward movement of the warmer (less dense) portion of the fluid and the sinking of the colder (denser) portion produces convection currents. Convection currents transfer energy from the hotter portion to the colder portion of the fluid. **Convection** is energy transfer by mass motion of a fluid such as air or water when the heated fluid is free to move away from the heat source.

Convection plays a major role in transporting energy in the atmosphere and in bodies of water. It also mixes pollutants from the ground within the lower atmosphere. The height that the pollutants can reach mainly depends on the convection activity (see Figure 4.27). One such factor that controls this is the temperature of the ground. The hotter the ground is the higher the convection current goes and the pollutants with it.



*Figure 4.27 Convection brings pollutants from the ground upward (G. Tubal)*



- Q4.10 (a) You want to let air into a stuffy room. Should you open the window from the top or the bottom if the outside temperature is warmer than the room temperature? (b) Where is it best to install an air conditioning unit, at the upper part of the room or at the lower part of the room? Why?

## Radiation

How does the energy from the sun get to Earth? Definitely, it could not be by conduction or convection because these processes need material medium to transfer energy from the hotter to the colder region. Remember that there is no material substance in some regions of the space between Earth and the sun.

Scouts are sitting around a bonfire. How does heat from a bonfire reach the scouts? Could it be because of convection? You have learned that convection is the upward movement of warm air but the bonfire and the scouts are at the same level.

Radiation, such as light, is carried by waves (electromagnetic waves). Energy transfer by radiation does not need any medium which explains why energy from the sun can reach Earth. Although it does not need any medium, radiation can also travel through gas as air. This is the reason why heat from a bonfire can reach the scouts.

- Q4.11 Explain why you feel hot when you are cooking or barbecuing. Use energy transfer through heat in your explanation.

## Lesson 4.8 Energy Sources

Look around you. List at least 10 objects that you see moving. Across each object write the energy source that enables it to move or to function. Now, describe what an energy source is. Can we consider the following things an energy source: a raised hammer, a stretched spring, hot flat-iron, and rotating electric fan? Can a person be an energy source?

An energy source is something that has vast amounts of energy. A raised hammer, once its potential energy is transferred, can no longer do work unless it is again supplied with energy. Hence, it is not considered an energy source.

The sun is Earth's main source of energy. It has a vast amount of energy.

### Activity 4.11 Energy Sources

#### Procedure

1. Do all energy sources derive their energy from the sun? Draw an energy flow diagram to show how those energy sources that derive their energy from the sun can really be traced back to the sun.
2. List energy sources according to the categories indicated in the table.
  - a. Why is the sun considered Earth's main energy source?
  - b. What are the energy sources that do not derive their energy from the sun? Where do their energy come from?
  - c. Differentiate renewable and non-renewable energy sources.

Energy Source That Derive its Energy from the Sun		Energy Source That Does Not Derive its Energy from the Sun	
Renewable	Nonrenewable	Renewable	Nonrenewable

The sun is considered Earth's main energy source since most of our energy sources derive their energy from it. Figure 4.28 shows the flow of energy from the sun. Almost all energy sources are renewable and only fossil fuel is nonrenewable.

A renewable energy source is one that can be replaced in a short period of time while a nonrenewable energy source takes a million of years to replace (fossil fuels) or can never be replenished (nuclear power).

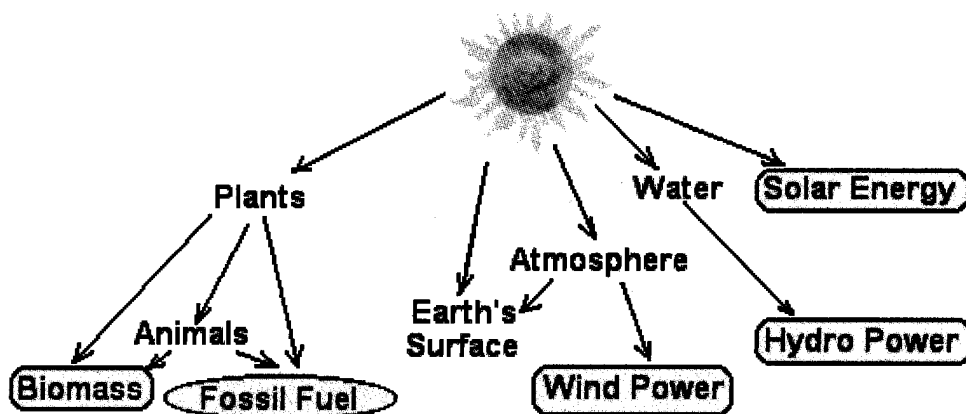


Figure 4.28 Energy sources that derive their energy from the sun

## Energy Sources: Derived from the Sun

The following are energy sources which derive their energy from the sun.

### Solar Energy

Energy from the sun can be used directly to warm and light our community, to heat water (through the use of solar water heater) in some big establishments and residential houses, and to provide electricity through the use of solar or photovoltaic (PV) cells. The electrical energy generated is stored in batteries. Electricity is also produced in solar thermal electric power where the sun's energy is concentrated to heat water and produce steam.

Harnessing solar energy on a large scale through solar or PV cells is best for places within 20° N and 20° S of the equator. According to the Department of Energy, about 3 957 systems of various PV applications are already located in the country with an equivalent capacity of 567 kilowatt-peak (kWp). PV is used not only to generate electricity but also various applications ranging from telecommunication, battery charging stations, PV-powered video cinemas, refrigerators, incubators, street-lights, and others.

### Hydropower

Energy from the sun drives the hydrologic cycle. Water when heated evaporates. Precipitation feeds water to rivers and streams which are then stored in dams and turned into hydropower. Water released from dams flows through turbines that turn generators that produce electricity.

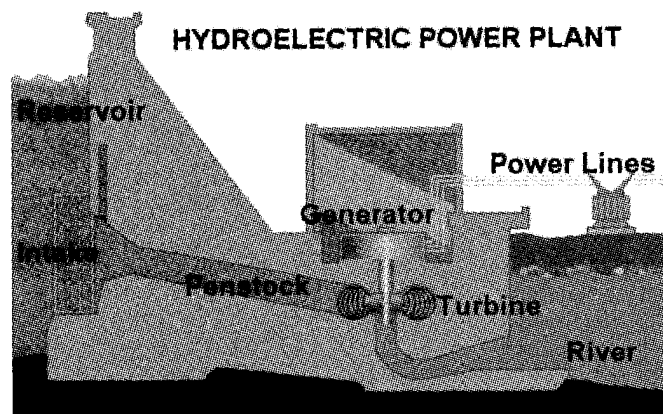
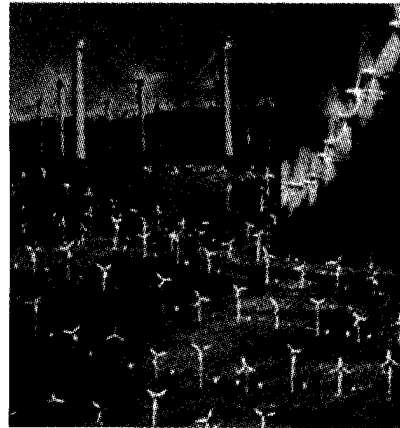


Figure 4.29 Schematic diagram of a hydroelectric power plant

Hydropower can be maximized by tapping a river, large or small, at several points from its source until it reaches the sea. Mindanao's electric power needs mostly come from hydropower due to the presence of the Maria Christina Falls.

## Wind Power

Different parts of Earth receive different amounts of sunlight. Also different Earth surface types (water or land) change their temperatures at different rates depending on the presence or absence of sunlight. Wind circulation results because of temperature differences of Earth's surface. To generate electricity using wind power, wind turbines are used. Their blades drive a generator that produces electricity. Wind turbines are placed on towers (Figure 4.30) because the wind blows harder and more steadily above the ground.



*Figure 4.30 Wind turbines*

Initial wind mapping done by PAGASA shows that there are many areas in the Philippines with good-to-excellent wind resource for utility-scale applications or excellent wind resource for village power applications, particularly in the northern and central regions of the country.

## Fossil Fuels

**Fossil fuels** are remains of plants and animals buried underground millions of years ago. The energy stored in plant remains was derived from the sun and those in animal remains, from food which they ate while they were still alive. Coal comes from dead plants that were buried by mud and sand. They formed layers of a spongy material called peat. Over many hundreds of years, the peat was covered by sand, clay, and other minerals, which through heat and pressure resulting from being buried over millions of years turned into sedimentary rocks. More and more rocks piled on top of more rocks, creating greater pressure on the peat. The great pressure squeezed the water out from the peat and eventually, over millions of years, turned into coal, oil or petroleum, and natural gas.

When the marine plants and animals died, their remains settled on the seafloor where they were buried by layers of sediment and fossilized. As the soft organic tissue was buried, heat and pressure transformed it into oil and gas: lower heat preserves oil whereas gas can survive to higher temperatures.

The Philippines has a vast potential for coal resources just awaiting full exploration and development in the different parts of the country. There are also some natural gas and petroleum fields discovered, mostly off coast in Palawan.

Fossil fuels are used to run vehicles and to generate electrical energy in fossil-fired thermal power plants. Here, fossil fuels are burned to boil water and turn it to steam. The expanding steam is used to rotate a turbine that rotates a generator that produces electricity.

### **Ocean Energy: Ocean Thermal Energy Conversion**

In tropical areas like the Philippines there is a temperature difference of some 20 °C between water at a depth of around 1 km and that on the surface. This temperature difference can be exploited for electrical energy generation similar to that of a conventional thermal power station. The warm surface water is used to evaporate a certain fluid and the colder water in the depths is used to condense it. The power plant can be on a ship or at the shore. Although the efficiency of conversion is very low, the resource itself is huge. So in principle, ocean thermal energy conversion (OTEC) could provide a significant electricity output.

### **Biomass**

Plants and trees depend on sunlight to grow and animals get their energy from plants; hence, biomass energy is a form of stored solar energy.

There are three ways to use biomass. It can be burned to produce heat and electricity, changed to a gas-like fuel such as methane, or changed to a liquid fuel. Liquid fuels, also called biofuels, include two forms of alcohol: ethanol and methanol. Because biomass can be changed directly into a liquid fuel, it could someday supply for transportation fuel needs of cars, trucks, buses, airplanes, and trains.

The Philippines, being an agricultural country, has great biomass resources such as wood wastes, bagasse, coconut and rice residues, animal wastes, and municipal solid wastes.

## **Energy Sources: Not Derived from the Sun**

The following energy sources do not derive their power from the sun.

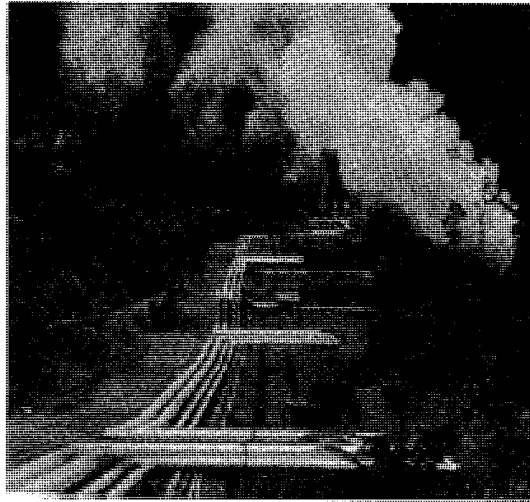
### **Geothermal Energy**

Geothermal energy refers to the energy which flows out from the center to the surface of Earth. Geothermal energy starts with hot, molten rock (called magma) found kilometres below Earth's surface that heats a section of Earth's crust. The heat rising from the magma warms underground pools of water known as **geothermal reservoirs**. Sometimes the water can even boil to produce steam. If there is an opening through the rock to the surface, the hot under-ground water may seep out to form hot springs, or it may boil to form geysers.

Geothermal energy is used to produce electricity in Laguna, Albay, Leyte, and near Mt. Apo. Our country remains the world's second largest user of geothermal energy for power generation.

### **Nuclear Power**

When the nucleus of certain atoms, like that in the element uranium, breaks down into other kinds of smaller atoms, they give off large amounts of energy. The energy released is called nuclear energy and is used in nuclear power plants to produce steam used to generate electricity.



*Figure 4.31 Steam pipes leading to the geothermal power plant*

In Morong, Bataan, a nuclear power plant was built. It was never made operational because many people objected to it because of its poor construction and its geological setting. The Philippines lies in an earthquake prone area and earthquake might weaken the buildings where the uranium fuels are. Uranium which is intended for use as fuel in the nuclear power plant has been found to emit radioactive rays for thousands of years that can destroy both plant and animal life. But if nuclear fuels are properly handled, it can be a vast source of cheap energy.

### **Tidal Power**

There are two high tides and two low tides that occur in a day. Tides are caused by the changing position of the moon relative to Earth. There are some coasts that are characterized by large tides. During high tides in these places, sea water that flows inland, usually in a river estuary, is used to rotate a turbine and generator in much the same way as water from a dam in a hydropower plant. After doing work on the turbine, the incoming sea water is stored in a storage pond. As a low tide sets in, the stored sea water goes back to sea. This outgoing sea water can again rotate the turbine. Thus, the incoming and the outgoing sea water during high and low tides respectively can be used to generate electricity.

The first and largest modern electric tidal plant was built in the 1960s and is situated at La Rance in France. It operates at 240 MW power. No such plant has yet been envisioned in the Philippines within the immediate future.

Of the energy sources mentioned above only fossil fuels and nuclear power are nonrenewable and the rest are renewable.

## Lesson 4.9 Energy Use

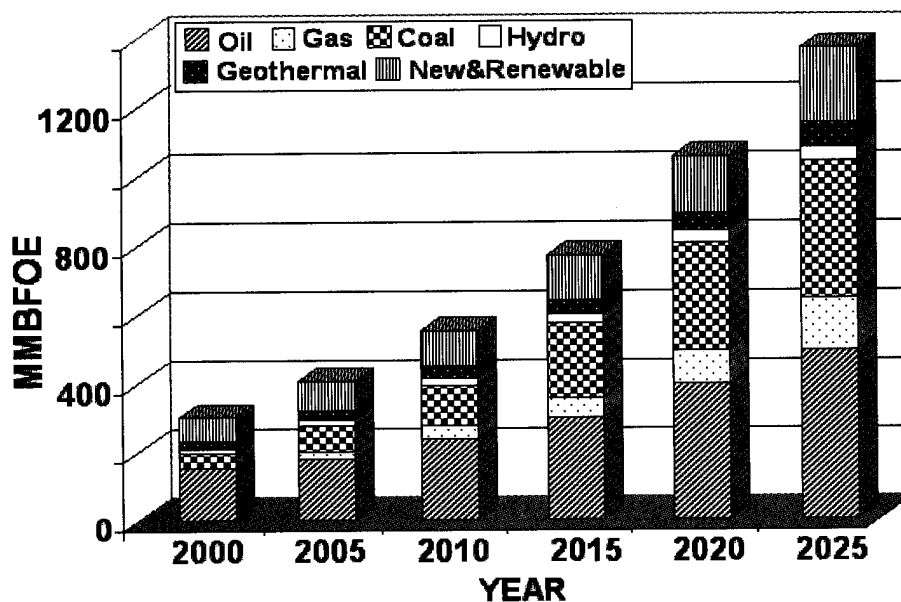
### Energy Supply

The Philippines is blessed with varied energy sources. Do these energy sources sufficiently supply our energy needs? To meet the increasing energy demands for the growing population, the Philippine Department of Energy has projected the following total primary energy mix or the proportion of energy sources that will be consumed for the period 2000 to 2025. Do Activity 4.12.

#### Activity 4.12 Energy Supply

##### Procedure

1. Analyze the graph that shows the total primary energy mix to meet our country's energy needs until 2025.
  - a. How much more is our projected energy need in 2025 compared to that in 2000?
  - b. What are the three energy sources that will be contributing largely to our energy needs until 2025?

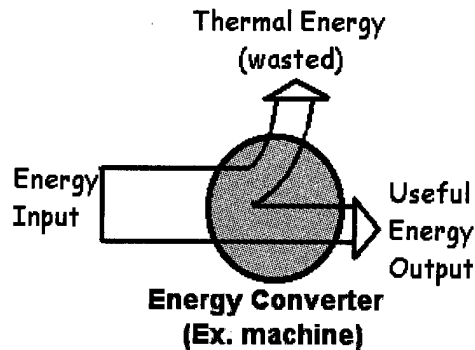


Total primary energy mix for the Philippines

- c. To meet our projected energy demands, fossil fuels will be used increasingly within the period. How much more fossil fuels will we need in 2025 compared to that in 2000?
- d. Fossil fuels are nonrenewable energy sources. Some project that the lifetime of oil may be within this century and for coal, about four centuries more. Some project that the world's oil supply will start to decline by 2020. The Philippine Department of Energy projected though that we will rely on 60% imported energy sources. Do you think we can import as much oil as we need by 2025? Why do you think so?
- e. How much more are we going to depend on new and renewable energy sources in 2025 compared to that in 2000?
- f. Of the new and renewable energy sources, wood and wood-wastes is the most significant contributor. The rest is a mix of bagasse, rice and coconut residues, municipal wastes, animal manure, and others. Which of these are found in your locality, which you can tap as energy source?

## Environmental Effects of Energy Use

The vast energy in energy sources is of no use if this is not transferred to do a useful process. However, in the process of its transfer, part of it is wasted and dissipated to the environment. A device or machine is used to transfer energy. Whenever machines are used, they always dissipate energy to the environment (Figure 4.32). The less energy a machine dissipates or the more useful form it transfers, the greater is its efficiency. Efficiency is just the ratio of the useful energy output to the energy input or



*Figure 4.32 Energy is always wasted as a product of energy transfer and transformation.*

$$\text{Efficiency} = \text{Useful Energy Output} / \text{Energy Input}$$

A more efficient machine conserves energy.



Q4.12 Suppose you want to buy a certain machine or appliance. An efficient brand is more expensive than another brand. Which one are you going to buy? Why?

Consider a bicycle with dynamo that is used to provide light for the cyclist at night. A bicycle dynamo is a small generator just like the hand-held generator shown in Figure 4.33. If the generator handle is not rotated the light bulbs connected to it do not light up. If it is rotated the bulbs light up. The lighting up of the bulbs shows that there is electricity in the circuit.

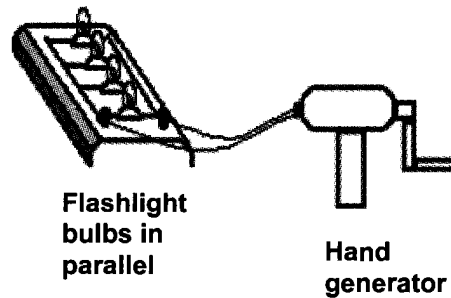


Figure 4.33 Hand generator bulbs circuit

There is electricity in your electric circuit at home because this is connected to a large generator in a power plant. The generator needs to be rotated to produce electricity. This cannot be

done by hand but by a large turbine (recall Figure 4.29). The turbine is rotated by water in hydroelectric and tidal power plants or by steam in fossil-fired, geothermal, and nuclear power plants.

If there are more bulbs or loads connected to the circuit, it is more difficult to rotate the handle. This is because more energy output is needed. Hence, greater energy input is required. If a community has more electrical energy needs just like when there are many electrical devices that are being operated all at one time, greater amount of energy sources are needed in electric power plants.

In the different power plants, electricity is not the only one produced but also pollutants and other bad effects on the environment. Look at the exhaust of vehicles. Vehicles use gasoline and diesel, which are much cleaner fossil fuels than those used in power plants; yet, they emit pollutants. Hence, pollutants from power plants due to fuel burning are expected to be worse. A summary of the environmental effects and other problems of operating the different power plants are given in Table 4.1.

Q4.13 Suppose your parents can easily pay your electric bills, are you going to use electrical energy for as long as you desire? Why or why not?

**Table 4.1 Environmental Effects of Operating Electric Power Plants**

<b>Electric Power Plant</b>	<b>Energy Source</b>	<b>Environmental Effects and Problems</b>
Fossil-fired Thermal Power Plant (PP)	Fossil fuel	<ul style="list-style-type: none"> <li>• Thermal and chemical pollution</li> <li>• Land for mining site disturbed</li> <li>• Fuel reserves depleted</li> </ul>
Nuclear PP	Uranium fuel	<ul style="list-style-type: none"> <li>• Thermal Pollution</li> <li>• Nuclear Radiation, nuclear wastes</li> </ul>
Geothermal PP	Geo-thermal	<ul style="list-style-type: none"> <li>• Chemical and thermal pollution</li> <li>• Ground from which hot water is drawn gradually lowers</li> </ul>
Hydroelectric PP	Hydro-power	<ul style="list-style-type: none"> <li>• Nonpolluting</li> <li>• Large land for dam (water storage)</li> </ul>
Wind Turbine PP	Wind	<ul style="list-style-type: none"> <li>• Nonpolluting</li> <li>• Nonconstant supply (storage battery needed)</li> </ul>
Solar PP	Radiant energy	<ul style="list-style-type: none"> <li>• Nonpolluting (in PP but thermal and chemical pollution where solar cell is produced)</li> <li>• Nonconstant supply (storage battery needed)</li> <li>• Big land area for solar panels</li> </ul>
OTEC	Ocean thermal	<ul style="list-style-type: none"> <li>• Transmitting generated power hundreds of km offshore</li> <li>• Operational energy requirement is greater than generated with present technology</li> </ul>
Tidal	Incoming and outgoing ocean waves	<ul style="list-style-type: none"> <li>• Affects sedimentation rate, salinity, oxygen content, and temperature of water</li> </ul>

## Using Energy Wisely

There are several reasons why you need to use energy wisely. First, because of the dwindling energy supply; and second, because of its environmental effects that lead to the deterioration of our environment.

What are the things you can do to conserve energy source? Energy sources, especially the nonrenewable but mostly in demand fossil fuels are used extensively in transport and in electrical energy generation. In transport, what are the practical ways that you can do to help? One is taking a walk or riding a bicycle instead of riding short distance trips using gasoline or diesel-fed vehicles. Practice car pooling or take mass transport if these are available in your community.

There are a lot of things you can do to conserve energy sources at home. Practice good cooking habits when using any kind of energy source. Reduce your electrical energy at home. What are the practical things you can do to reduce this without sacrificing your comfort and convenience?

**Lighting:** ▪ Use natural light whenever possible. ▪ Turn off lights when not in use. ▪ Use compact fluorescent lights (CFL) instead of incandescent bulbs. A 16-watt CFL produces the same light as a 60-watt incandescent bulb at a quarter of the energy cost. ▪ Clean light bulbs regularly. Dirt lessens illumination by as much as 50 percent. ▪ Use low wattage light bulbs in areas that do not need strong lighting. ▪ Use lamps that provide direct lighting over desks, beds, and other work areas.

**Refrigerators:** ▪ Give it room to breathe. Place refrigerators at least 4 inches away from the wall so as not to overwork the motor. ▪ Close it properly and defrost regularly. ▪ When buying new refrigerators, be sure to purchase energy efficient models.

**Cooking:** ▪ Prepare all ingredients before cooking to avoid frequent switching on of electric stove. ▪ Thaw frozen food thoroughly before cooking. ▪ Match pots and pans to stove element. Avoid using a big burner for a small pan to lessen heat transfer loss. ▪ Cover pots with lids to prevent heat from escaping. ▪ Use flat-bottomed pots and pans when using electric stove. They provide faster heat transfer than pots with rounded bottoms. ▪ Turn off the electric stove during the last minutes of cooking. The remaining heat will make the food simmer.

**Ironing:** ▪ Do all ironing at one time. ▪ Iron clothes during cooler hours of the day. This helps lessen the demand for electricity during peak hours. ▪ Dampen clothes moderately. Excessive moistened clothes take longer to iron. ▪ Switch off the electric iron in the last few minutes of ironing. The remaining heat will be enough to press the last few clothing.

**Other Appliances:** ▪ Unplug all electronics when not in use. ▪ If a transformer or voltage regulator is used, unplug it from the outlet and turn it off. Transformers consume more electricity when it heats up. ▪ Appliances will operate more efficiently and use less energy when they are in good working order than not maintained ones. ▪ When using electric fans, lock the oscillator when fan is needed in one direction only, thus, air is blown directly where needed. ▪ Clean fan blades and motor regularly to keep it running efficiently.

## SUMMARY

The presence of (an unbalanced) force on an object can be determined by its effect as deformation of the object or a change in its motion. The effects of force on motion are embodied in Newton's Laws of Motion.

The four fundamental forces in nature are gravitational force, electromagnetic force, strong nuclear force, and weak nuclear force. Gravitational and electromagnetic forces are very evident in our daily experiences.

Energy is the ability to do work and to make other things get hotter. The different aspects of energy are as follows:

- It has different forms: (a) mechanical (kinetic and potential energy), (b) chemical, (c) electrical, (d) radiant, (e) internal, (f) sound, and (g) nuclear energy.
- It can be transformed from one form to another.
- It can be transferred.
- Energy is always conserved.
- The value of the useful form of energy is degraded during energy transfer and transformation since thermal energy is always produced. Mechanical and electrical energies are the forms of energy with highest value while internal energy especially at low temperature has the least value.

Energy can be transferred through work and heat. The three ways of energy transfer through heat are conduction, convection, and radiation.

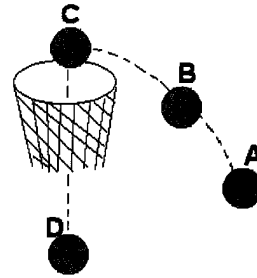
## SELF-TEST

### I. Multiple-Choice Items

Choose the letter of the correct answer.

1. What force enables you to walk on the ground?
  - a. the downward force on the ground due to your weight
  - b. the backward force on the ground from your feet
  - c. the upward force of the ground that supports you
  - d. the forward force of the ground on your feet
2. Amae feels liquid pressure as she goes at different depths in a swimming pool. How will she feel liquid pressure?
  - a. It is constant anywhere in the pool.
  - b. It increases as the depth increases.
  - c. It decreases as the depth increases.
  - d. It depends on the swimmer's position.

For items 3 and 4, refer to the figure at the right.



3. A basketball is thrown into a goal as shown in the figure. At what point does the ball have the greatest potential energy?
  - a. A
  - b. B
  - c. C
  - d. D
4. What statement best describes the energy of the basketball as it falls from point C?
  - a. Its kinetic energy increases.
  - b. Its potential energy increases.
  - c. Its mechanical energy increases.
  - d. Both its kinetic and potential energy remain constant.
5. Why are cooking utensils provided with wooden handles?
  - a. Wood is cheaper than steel.
  - b. Wood is light and easy to handle.
  - c. Wood is a poor conductor of heat.
  - d. Wood is more attractive than steel.
6. Which of the following situations happen because of convection?
  - a. Heat from the sand felt by the person walking on the beach.
  - b. Heat from the sun felt by a person lying on the beach.
  - c. Sea breeze felt by a person sitting by the beach.
  - d. Clouds forming over the beach.

## II. Open-ended or Constructed - Response Items

Answer the following.

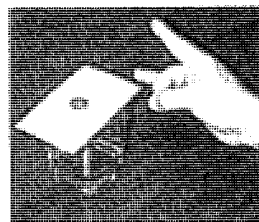
1. Compare the velocities of each pair of bodies or objects by writing equal or not equal. Explain.
  - A. Car A is running at 70 km/h, north and Car B at 60 km/h, north
  - B. Cyclist A is negotiating a curve with a speed of 6 m/s and cyclist B with a speed of 6 m/s along a straight path
  - C. Friends A and B approach each other with the same speed
  - D. A man and his dog are jogging side by side on a sidewalk
2. Compare the cost of using the following devices in 30 days if 1 kW-h costs P6.00. Assume that each device has been operating for an equal number of hours per day as indicated in the second to the last column of the following table.

Appliance	A		B		Ave. No. of Hrs/Day Used	Cost Difference/ Month
	Features	Power Rating (watts)	Features	Power Rating (watts)		
Desk Fan	12"	50	16"	80	14	
Flatiron	standard	600	de luxe	1 000	1	
Stove (hot plate)	6"	1 500	8"	2 500	2	
TV Set (colored)	12"	65	26"	150	12	
Light Bulb	fluorescent, 21" with ballast	32	incandescent	100	14	

3. Choose the letter/s of the statement/s that is/are true.
- A. Equal force is needed to move two objects of equal mass with the same acceleration.
  - B. When two objects have equal masses, the one on which greater force is applied moves with greater acceleration.
  - C. To move two objects with the same acceleration, the one with greater mass requires greater force.
  - D. When the forces applied on each object are equal, the object with greater mass moves with greater acceleration.

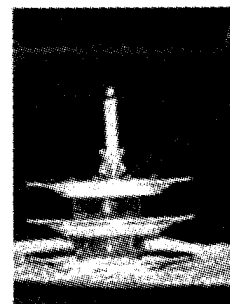
4. Many tricks apply the law of inertia. Explain why the following can be done.

A. The coin drops into the drinking glass if the cardboard is suddenly flicked.



B. The stack of plates and glasses stay in place if the tablecloth underneath is suddenly pulled.

C. Some people get rid of water from their wet umbrellas by abruptly closing and opening them several times. Some turn their umbrellas around. Can the law of inertia explain the effectiveness of such practices? Why?

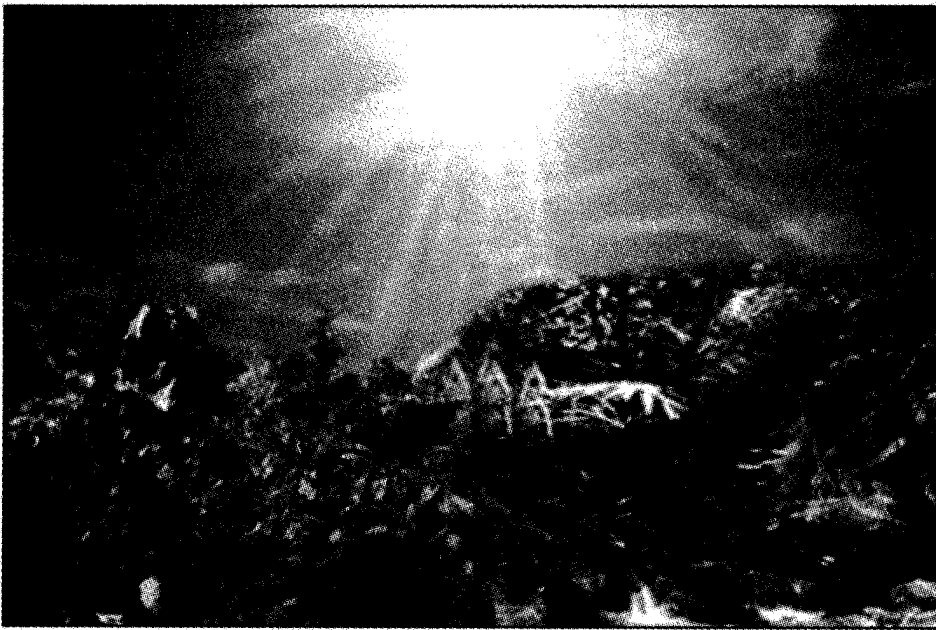


5. Write the predominant energy transfer that occurs or is prevented in the following situations and devices.

- A. thermos bottle
- B. use of rubber slippers on beach sand at noon
- C. sea breeze
- D. use of metal in pans
- E. use of incandescent bulb in little chick's house

## Unit V

# Ecosystems: Components, Characteristics, and Resources



You have been to a flower garden, a rice field, a pond, or a coastal area. These are ecosystems. Some of these are natural while others are human-made. What are the components of an ecosystem? What characteristics are common to all ecosystems? What makes each ecosystem unique? How important are ecosystems to living things and their physical environment?

This unit will familiarize you with the different ecosystems, the interactions between and among living things and between the living and nonliving components of that ecosystem. In addition, it will discuss how natural phenomena and human activities create imbalance in these ecosystems. It will help you plan activities, including the use of appropriate technologies, that will help restore the balance, as well as protect and sustain resources for present and future generations.

Hopefully, you will realize that everything on Earth is connected to everything else and that the quality of the ecosystems will affect the quality of life for everyone.

## Lesson 5.1 Components of an Ecosystem

In nature, living things exist in association with a few or many other plants and animals. Plants need sunlight, water, and nutrients from their surroundings. The interdependent living and nonliving components enclosed within a definite boundary is called an **ecological system** or **ecosystem** for short: *eco* refers to the environment and *system* indicates organized units.

What living things exist in particular ecosystems? What conditions enable them to survive in such environment?

### Activity 5.1 Observing Living and Nonliving Things in a Quadrat

#### Materials

4 sticks (one metre long each)  
thermometer  
record book

hand lens  
pointed sticks

#### Procedure

1. Lay down the four sticks such that they form a square. Square study sites are called quadrats.
2. List the number and kind of plants and animals in each quadrat. Make a table for this data similar to one given below. You may have to loosen the soil for animals that may be staying beneath the surface. Use the pointed sticks for this. Use the hand lens to examine the small living things in the quadrat. A sample plant and animal you might see there are listed below.

Plants	Number	Animals	Number
grass		grasshopper	

3. Observe the soil within the quadrat in terms of its color, size of particles (fine, coarse, mixture of fine and coarse), type of soil according to texture (use Figure 5.1 to classify soils), and condition of the soil (wet, dry, flooded).
4. Take the air temperature by swinging overhead the thermometer in the air for about five minutes. Do not touch the bulb of the thermometer.



5. Take a reading of the thermometer by measuring the height by which liquid inside the thermometer rose against the scale.
6. Observe the intensity of the sunlight reaching the quadrat. Is the quadrat under a shade or is it under full sunlight?
  - a. Write one general statement each for your observations in steps 2 to 5 above.
  - b. How do you think the nonliving components of the environment affect the living components and vice versa? Give an example for your answer.

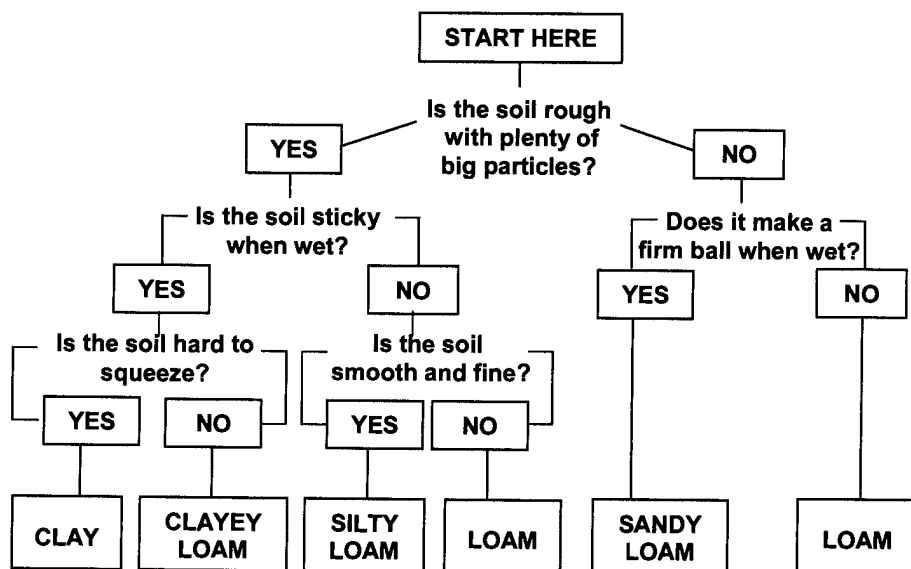


Figure 5.1 Soil texture key

The sites you studied are examples of ecosystems. Any group of living and nonliving things interacting with each other can be considered an ecosystem.

Ecosystems vary in kind and size. It can be a rotting log, a portion of a forest, a farm, a riverbank, or a part of a coastal area. It can also refer to the whole area of these sites mentioned.

Q5.1 Is the biosphere or the thin layer of Earth where the lithosphere, the hydrosphere, and the atmosphere meet an ecosystem? Why or why not?

### Home Activity

Observe any two of the following ecosystems: a rotting log, a flower garden, a beehive in the garden, or whatever place in your community that is of interest to you. Identify the plants and animals present in each study site. Describe the environmental conditions that you think favor the survival of the plants and animals in those areas.

## Lesson 5.2 Biodiversity in Ecosystems

The place where groups of plants and animals live at the same time is called **habitat**. Large ecosystems like the forest and sea are habitats for a great variety of plants and animals. Rivers are habitats of crocodiles and freshwater organisms. Grasslands are habitats of grasshoppers and other insects.

Biodiversity is a characteristic common to all ecosystems. The Philippine forests, for example, are reported to be among the most diverse forests in the world.

In terms of species, there are about 13 500 plant species representing 5% of the world's flora, 32% of which are endemic to or found only in the Philippines. Of these plant species, 8 000 species are flowering, 3 200 of which are unique to the country. Animal species, mostly insects, total about 170 000, half of which are endemic.

Unfortunately, many plants and animals in the country are also reported to be among the most endangered. Some of the animals in the endangered list are the Philippine monkey-eating eagle, tarsiers, tamaraw, and bleeding heart pigeon. See Figure 5.2. Some of our orchids and medicinal plants are also in the endangered list.

The major reason for the disappearance of our important life forms is destruction of their forest habitat. As of 1994, the Philippines has only about 5.6 million hectares of commercial forests left. The 27.5 million virgin forests in 1575 has been reduced to 800 000 in 1994. Forest reduction is caused by a combination of the following activities: shifting cultivation or *kaingin*, uncontrolled logging, mining, overgrazing, and conversion of land into subdivisions. Forest destruction does not only affect biodiversity but also the watersheds and the supply of freshwater as well.



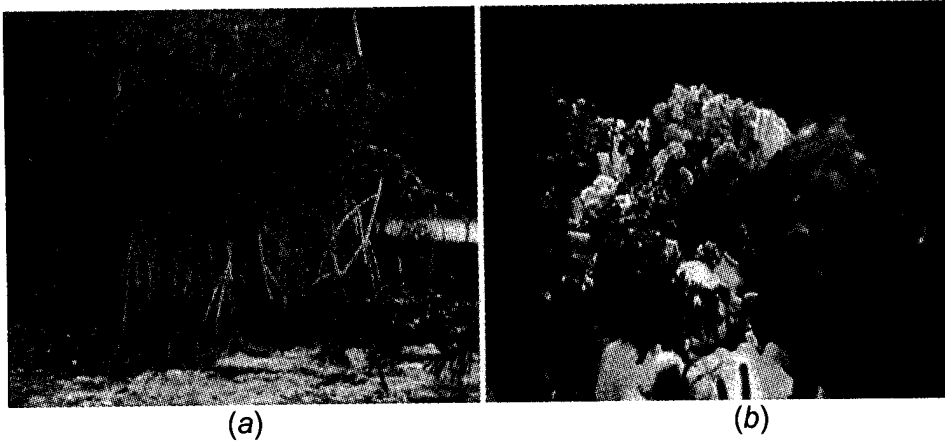
*Figure 5.2 Some of the Philippines' endangered animal species. Can you identify them? How do you contribute to their decreasing number?*

Have you seen a group of woody, salt-tolerant trees growing near the coastal area? These are mangroves. They provide nursery ground for many fishes and other organisms that live in the sea. Crabs, shrimps, and other crustaceans are found in these areas. Mangroves provide food and shelter for many organisms both above and below the water. They also serve as protection against land erosion and storm damage.

The other ecosystem that is admired not just for its beauty but for the numerous kinds of living organisms that reside there are the coral reefs. Coral reefs are home to different types of corals, hundreds of species and fishes, octopus, lobster, shrimp, sea worm, and many others. See Figure 5.3.

#### **Home Activity**

Identify the major ecosystems in your community. Interview some elders about animals and/or plants found in those ecosystems. Which of these plants and animals are in the endangered lists? What causes them to become endangered?



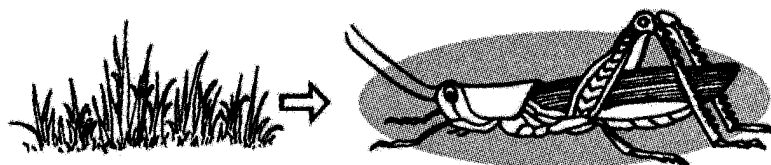
*Figure 5.3 Mangroves (a) and coral reefs (b) are coastal ecosystems. The Philippines has broad areas of mangroves and coral reefs. Why are these ecosystems important to people and the physical environment?*

## **Lesson 5.3 Living Things Depend on Other Organisms for Food**

Recall the living things found in the school ground. Did you notice that the grasshopper fed on the grass? Grasshoppers are dependent mainly on grass for food.

Some animals feed on other animals. But ultimately it can be said that all animals depend on plants for food. Thus, plants are “eaten” and the animals are the “eaters.” In science, the eaten plants are often referred to as producers. They can produce or manufacture their own food. The “eaters” are called consumers. All animals are consumers because they cannot manufacture their own food. They are dependent on producers, the plants.

The grass-grasshopper relationship described is a producer-consumer relationship. Take note of the direction of the arrow. The arrow points from the producer (grass) to the consumer (grasshopper).



*Figure 5.4 One kind of interaction between living things is based on food.*

**Q5.2** Suppose the grasshopper is in turn eaten by a frog, how would you represent the relationship among these three living things?

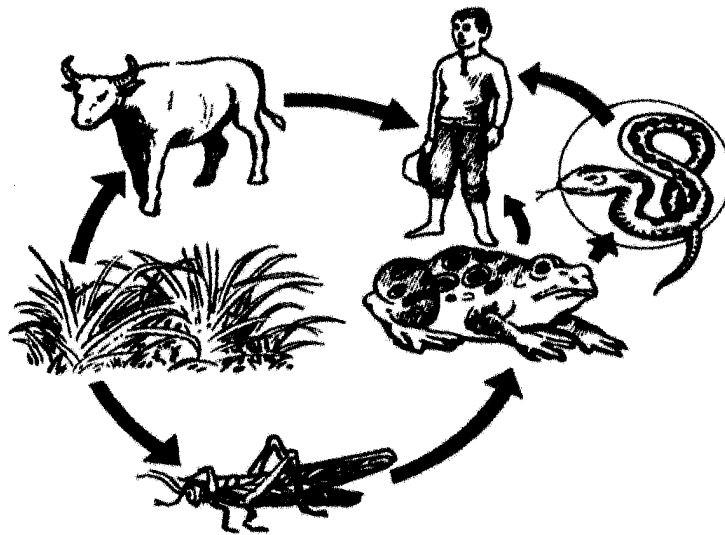
What you have just drawn represents a simple food chain. A **food chain** is a series of eaten-and-eater relationship or a series of producer-and-consumer relationship based on food. The producers are always at the beginning of any food chain.

The grasshopper that feeds on grass is called a first-order consumer. The frog that eats the grasshopper is a second-order consumer. The number assigned to the consumers is based on its position in the food chain. If a snake eats the frog, the snake becomes a third-order consumer.

Q5.3 If an owl eats the snake, what order of consumer is the owl?

Q5.4 Give other examples of food chains found in a garden or another ecosystem in your community.

The food chain consisting of a producer, a first-order consumer, or even a third-order consumer is a simple **food chain**. Study Figure 5.5. How many food chains do you find? Make a list of these food chains.



*Figure 5.5 Several food chains can exist in an ecosystem*

The figure shows several food chains which are connected to one another. This is how you find food chains in nature. An organism may be a part of several food chains. This complex relationship or interaction among living things is called a **food web**.

Q5.5 What will happen to the other organisms in the food web if all frogs in that ecosystem were killed?

Q5.6 Some of the organisms in a farm are listed: chicken, snake, duck, caterpillar, rice plant, snail, hawk, and humans. Make a food web out of these organisms.

There are other organisms in nature. **Decomposers** are organisms involved in rotting or in the process of decomposition. They consist mostly of fungi and bacteria. Fungi include such organisms as molds, mushrooms, shelf fungi, and puffballs. Bacteria, on the other hand, are microscopic single-celled microorganisms.

Q5.7 Using the food web in Figure 5.5, point how decomposers become part of the web.

As with other organisms in the ecosystem, decomposers are not an end in themselves. Bacteria and fungi are important food for other organisms such as protozoan, mites, insects, and worms living in the soil or water. Many of the fungi are also considered a great delicacy by people.

Thus, there are links between the decomposers and other consumers. When a fungi or other decomposers die, their dead bodies become part of the detritus and the source of energy for other fungi or other decomposers.

## Lesson 5.4 Other Interactions Among Living Things

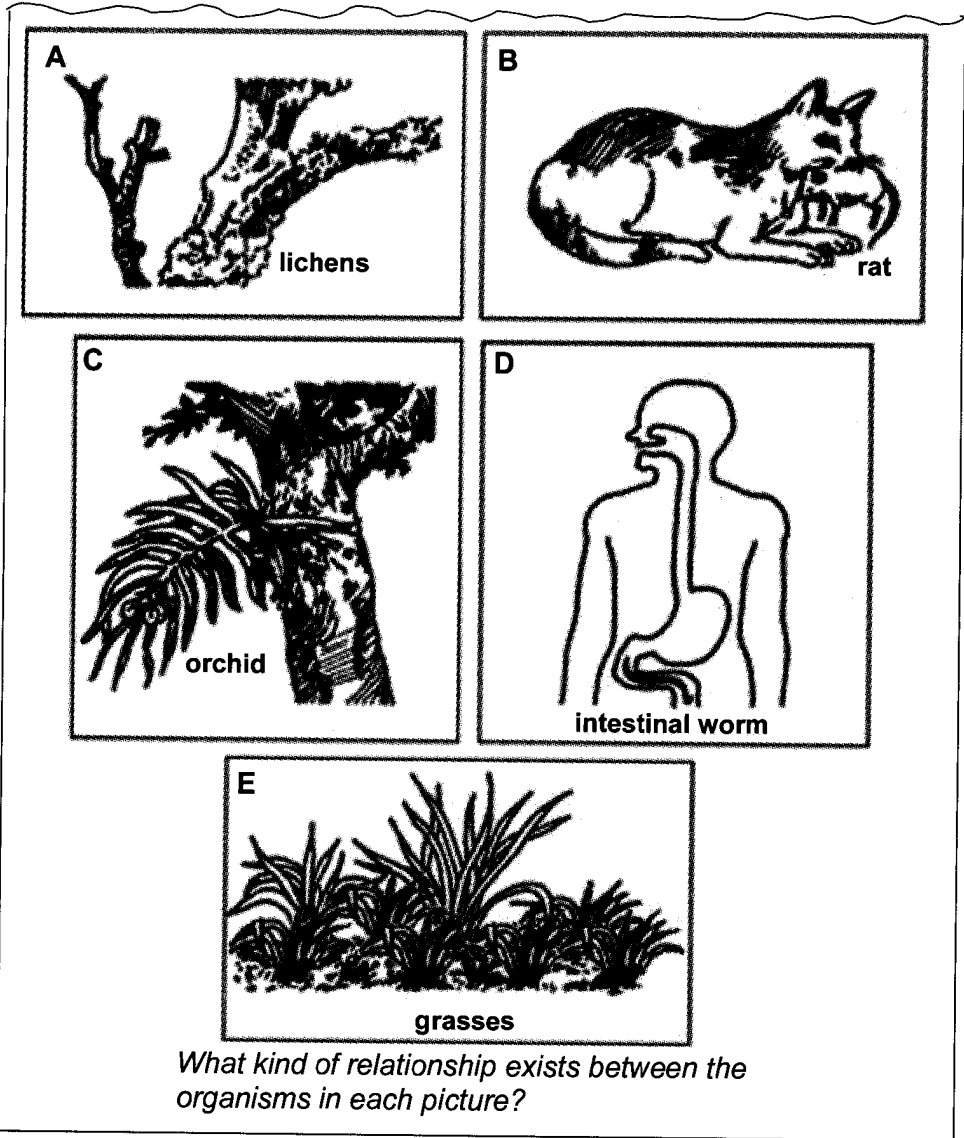
Besides dependence on food, organisms in an ecosystem interact with each other. Do Activity 5.2 to find out what other interactions occur.

### Activity 5.2 Who Benefits? Who Gets Harmed?

#### Procedure

1. Study the five pictures on the next page. In each picture
  - a. identify the organisms.
  - b. look for the relationship between organisms using the symbol (+) if the organism is benefited; (-) if the organism is harmed; and (0) if the organism is not affected.
2. Present your data in a tabular form similar to the one shown below.

Picture	Organism Benefited (+)	Organism Harmed (-)	Organism Not Affected (0)	Relationship
A				
B				
C				
D				
E				



Consider Situation A. You find lichens growing on trunks of trees. A **lichen** is made up of two kinds of plants—an alga and a fungus. The alga is a tiny green plant that lives within the body of the fungus. It can manufacture food for itself and for the fungus. The fungus, meanwhile, protects the alga from drying up. The alga and the fungus are different species but they manage to live together harmoniously, each benefiting the other. This is a typical example of a give-and-take relationship. When both organisms are benefited, the relationship is called **mutualism**.

Q5.8 Describe other examples of organisms that show mutual sharing of benefits.

The cat in Situation B has captured a rat and is about to eat it. The cat benefits by eating the rat, but the rat loses its life. The organism that does

the eating is called the **predator** and the organism that gets eaten up is called the **prey**. This kind of a relationship is called **predation**.

Q5.9 Between the cat and rat, which is the predator? Which is the prey?

Q5.10 Give other examples of predator-prey relationship.

Look at the orchid growing on a tree trunk (C). It attaches itself to the tree for support. The tree is neither harmed nor benefited by this arrangement. The organism that actually benefits is called the **commensal**. The other organism that is neither benefited nor harmed is called the **host**. This relationship is called **commensalism**.

Q5.11 Between the tree and the orchid, which is the host? Which is the commensal?

Intestinal worm inside the boy's intestine is an example of a relationship where one is benefited while the other is harmed (Situation D). The host (boy) loses some of his food to the ascaris. While it is true that the host continues to live in spite of the presence of the parasite, in severe cases, (too many parasites in one host), the host may become too sick and die.

Q5.12 Name other parasitic worms that infect humans and animals. Explain how each affects the health of the host.

**Parasitism**, as the relationship is called, also exists in plant life. If you look closely at some plants in the garden, you would probably see several wrinkled and dried leaves. Inside these dying leaves are young insects (larvae) or even mature insects living and feeding on the leaves. If they eat up most of the leaves, the plant may die. How can this happen? Recall the role of leaves in the manufacture of food for plant's use.

Have you seen grasses growing tall and crowded in one small area? These grasses are trying to outgrow one another by reaching out for sunlight which help in the manufacture of food. Where they are crowded (Situation E), others may actually grow taller, but would be thinner than when they have enough space around and between them. They may be of the same species but observe how they compete with one another for sunlight and soil nutrients. **Competitive relationship** exists between plants or between animals of the same species.

Q5.13 Give examples of animals that show competitive relationship.

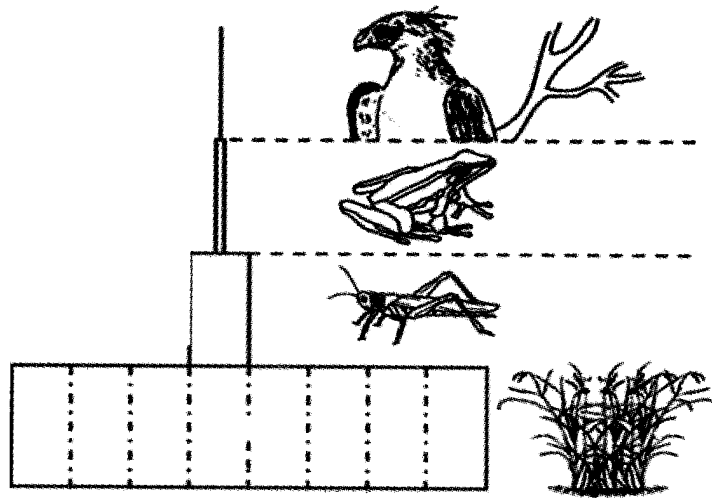
Your study of different ecosystems shows that organisms do not live alone. Under natural conditions, all plants and animals have to depend on one another to survive. Humans are part of this interdependence among organisms. We have a role to play in maintaining the delicate balance between living things and their environment. You will learn more about this later.



- Q5.14 Enumerate the five kinds of interrelationships among organisms. Give other examples to show the interaction.
- Q5.15 All life forms are important. Explain this statement in your own words.

## Lesson 5.5 Energy Flow in an Ecosystem Is Unidirectional

The sun is the main source of energy of living things on Earth. Plants are able to manufacture food because of the energy they absorbed from sunlight. In a food chain, the producer (the plant) is the source of energy. The producer uses part of this energy for growing more leaves and branches, for bearing flowers and fruits, for absorbing water from soil, in short, for maintaining life. Most are given off in the form of oxygen. In fact about one-tenth of the energy in plants is passed on to the consumers. The consumer, in turn, uses up the energy it gets from the producer for its own life-sustaining processes such as breathing, digesting, absorbing, and making the food part of its own body, and excreting that which is not used up. See Figure 5.6.



*Figure 5.6 Energy flow among organisms. Why do you think is the producer level base wider than the last consumer level?*

The base represents the producer (plant) which is most efficient in capturing energy. Note that the level immediately after the base where you find the grasshopper (first-order consumer) is smaller than the base area occupied by the grass. This means that the amount of energy given by the grasshopper to the frog is less than the amount of energy the grasshopper gets by eating grass. The frog (second-order consumer) also gives a relatively smaller amount of energy to the hawk than what it gets from the grasshopper.

Each consumer, regardless of the level it occupies in the pyramid, retains only about one-tenth of the energy of what it has consumed. The remaining bulk of energy (9/10) is used up in the process of actual living. Therefore, any given amount of energy at the producer's level decreases as it is transferred from one level to the next. Very little of the original given energy reaches the top. When put to a diagram, this is called the **energy pyramid**.

Q5.16 In your own words, describe what happens to energy as it goes from the producer up to the fourth-level consumer.

Q5.17 In Figure 5.6, what must the hawk do to have as much energy as the energy of the grass at the base?

Food is the source of energy for all living organisms. The energy flow from producer to the different levels of consumer follows a one-way path. Once energy has been used up, it cannot be recycled. Most of it is dissipated to the surroundings as thermal energy. It can, however, be produced or generated from the same or other sources. Still, the ultimate source of energy of Earth's ecosystem is the sun.

## **Lesson 5.6 Matter in an Ecosystem Goes Through a Cycle**

Aside from food, there are other materials in the environment on which organisms depend on to survive. In an earlier unit, you learned that the smallest particle by which matter can be identified is called a molecule. So we have a water molecule, a carbon dioxide molecule, and a sugar molecule.

Molecules are made up of elements, such as carbon, oxygen, hydrogen, nitrogen, and iodine. A water molecule consists of hydrogen and oxygen. A sugar molecule consists of carbon, hydrogen, and oxygen. Fertilizer sold in the market is made up of elements, usually nitrogen, phosphorus, and potassium (NPK).

At least 117 elements are known on Earth, 94 of which are naturally present in soil, water, air, and in plants and animals. Others can be prepared inside a laboratory. Elements in the environment exist singly, in groups, or in combination with other elements. Therefore, if matter is made up of molecules, and molecules are made up of elements, then we can say that matter is also made up of elements.

Cycles of matter refer to the cycles of elements. Why do we say that the movement of elements in nature occurs in a cycle?

## The Carbon and Oxygen Cycle

Look at Figure 5.7. Follow the arrows (the path taken by carbon) as you read the paragraphs that follow.

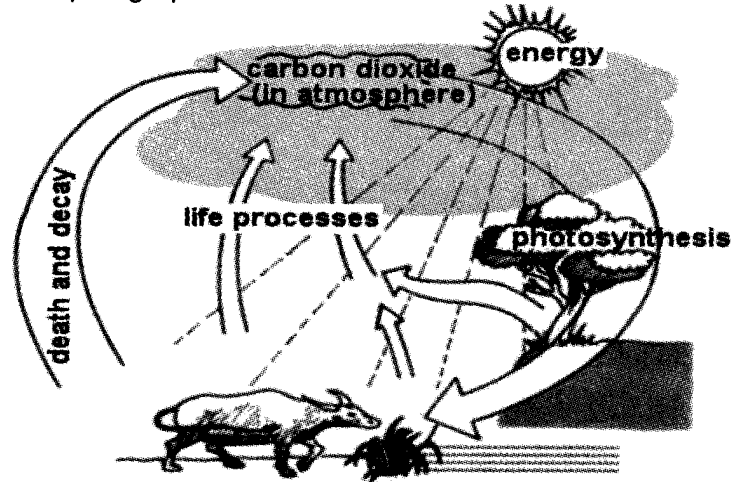


Figure 5.7 Plants and animals depend on each other for carbon dioxide and oxygen, respectively.

Carbon (in the form of carbon dioxide from the air), water, and other elements from the soil, and energy from the sun, are used by plants to manufacture their own food. This process of food manufacture in plants (photosynthesis) can be summarized in a simple way, thus:



Figure 5.8 Essential elements for the manufacture of plant food

Plant food, which is mainly sugar or starch, is passed on to the consumer (animals). These are broken down into forms and sizes that can be readily absorbed by their bodies. The process of breaking food, however, requires oxygen. It releases energy for use by other animals for different life activities. One such activity is the formation of large molecules that eventually become part of the organism itself.

The breaking down of food gives off carbon dioxide. See Figure 5.9. Note that carbon (in the form of carbon dioxide) goes back into the air whenever animals exhale. Note also that the process of food manufacture in plants is exactly the reverse of the breakdown of food in animals.



Figure 5.9 Breakdown of food in animals

When plants and animals die, their bodies still contain the molecules of carbon and other elements. Decomposers (bacteria of decay) act on the dead body releasing energy for their own use. Thus, more carbon dioxide and other molecules of carbon are released in the environment.

Where does the oxygen used by animals come from? Look at Figure 5.7 again. When plants manufacture food, oxygen is given off. This process contributes much to the 21% oxygen present in the air. In turn, oxygen is inhaled by animals and humans. The amount of oxygen needed by different animals may vary. In general though, large amounts of oxygen are needed to carry on life activities.

Q5.18 Refer to Figures 5.7 to 5.9 when answering the following questions:

- a. Why do plants need carbon dioxide?
- b. What becomes of the carbon atoms in the body of organisms?
- c. How does carbon dioxide go back to the atmosphere?
- d. What process gives off oxygen to the atmosphere?
- e. How is oxygen used by animals?
- f. In your own words, describe the carbon and oxygen cycle.
- g. Why is it called a cycle?

The burning of oil in factories and motor vehicles releases carbon dioxide to the atmosphere. With so much carbon dioxide returning to the atmosphere, it is equally important to have a large number of producers (plants) to use it up again and continue the cycle. Scientists are very concerned about the increased amount of carbon dioxide now found in the atmosphere. They are concerned about the imbalance in the cycle caused by flagrant, yet illegal, cutting down of trees and rapid increase in volume of industrial wastes. Planting more trees in the cities and countryside will offset this imbalance in the carbon and oxygen cycle.

## The Nitrogen Cycle

Nitrogen is present in the air and in the soil. Nitrogen in the air cannot be directly absorbed by plants. How is nitrogen in the air made available to plants?

Look at Figure 5.10. Follow the path of nitrogen as you read the succeeding paragraphs.

Lightning changes the nitrogen in the air into another form called **nitrate**. The nitrate is brought down to the soil by rain. Nitrate is the only form of nitrogen that can be absorbed by plants through its roots. Some of the nitrates remaining in the soil are acted upon by denitrifying bacteria converting them into nitrogen oxides, ammonia, or free nitrogen. Nitrogen escapes back into the air and the cycle continues.

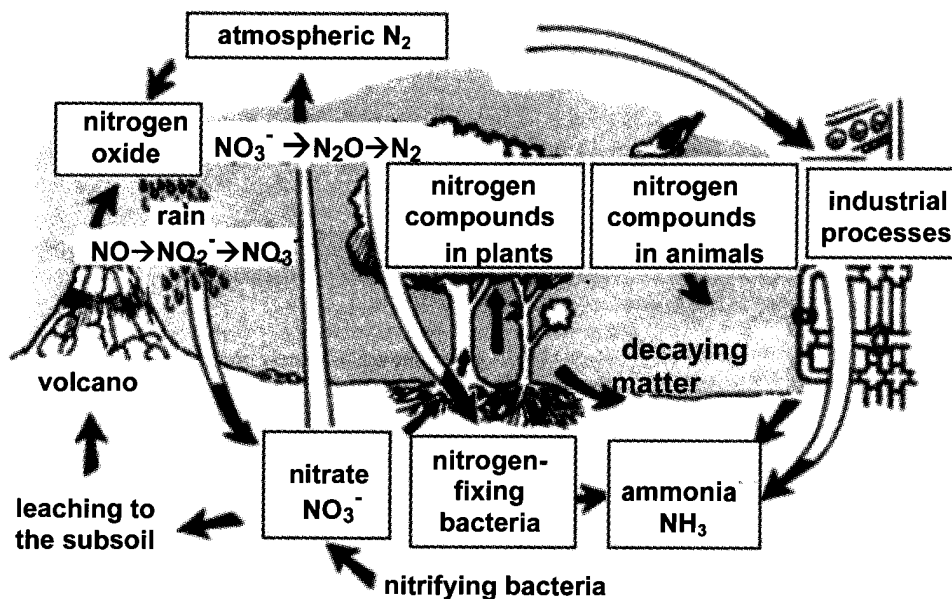


Figure 5.10 Nitrogen in the environment also goes through a cycle.

Another pathway by which nitrogen becomes available to plants is through leguminous plants. Beans and mung are examples of leguminous plants. They have enlarged structures in their roots called nodules where a kind of bacteria lives. These bacteria can “fix” nitrogen from the air and convert it to nitrates. Remember, plants can absorb nitrogen in the form of nitrates.

Azolla, a small aquatic plant found in water-filled or swampy areas, is a good source of nitrogen. On its leaves live the blue-green algae. Together, they “fix” nitrogen from the air. Azolla grows rapidly. One ton of fresh azolla contains 2.1 kg of nitrogen, 1.25 kg of phosphorus, and 1.75 kg of potassium.

Presently, the nitrogen in the farm soil comes largely from fertilizers. Fertilizers are directly applied to soils planted with crops. The aim is to provide or add more elements needed for plant growth. Later, you will learn why adding too much fertilizer in soil does not necessarily fertilize the soils.

How do animals use the nitrogen from plants? We know that animals consume plants for food. These plants contain not only sugars and starches, but also other molecules containing nitrogen. These molecules are broken down into smaller molecules that can be absorbed by organisms. The molecules containing nitrogen combine together and form protein—a large molecule needed by animals to grow. Protein molecules essentially become part of the organism itself.

Q5.19 Refer to Figure 5.10 when answering the following questions:

- a. What are the different ways by which nitrogen in the air reaches the soil?
- b. How is nitrogen returned to the atmosphere?
- c. Where do humans get nitrogen in their diet?
- d. Draw the nitrogen cycle in your own way. Include leguminous plants in your drawing.

When plants and animals die, their bodies are acted upon by decomposers. They become part of the soil. The layer of soil with decomposed matter from dead plants and animals is called **humus**. Soils that have plenty of humus are very fertile soils.

Q5.20 Why are soils with humus fertile?

Q5.21 Some farmers, after gathering mungo seeds, plow back the plants into the soil. Is this a good farming practice? Why?

Q5.22 Multiple cropping (planting different crops in one field) is also practical in many areas in the Philippines. Explain the advantages of this farming method.

You have learned that matter (in the form of elements) taken out from one part of the environment is recycled back to the environment. There is a cycle of using, returning, and reusing the elements in the environment. Organisms are dependent on these elements for maintaining life.

Is matter lost when they are converted from one form to another? Consider this analogy. When you drink milk or coffee, you add sugar to water, mix the solution and the sugar dissolves. If you take the mass of the sugar solution it will be the same as the mass of sugar and water before the actual mixing. We say, therefore, that mass is not lost. This is also true in nature's processes.

Simply put, matter is said to have undergone conversion when there is an apparent change in the property of said matter in terms of form, state, composition, or character. In nature, however, matter is not only converted to another form, but is also transferred from one part of the environment to another.

Q5.23 Do you think composting is a way of conserving elements in nature? Explain your answer.

Q5.24 How are elements transferred from one environment to another when using compost in farming?

Note that the water cycle is not discussed in this unit. It is true that water circulates in the biosphere just like carbon and the others through the biotic and abiotic components and with the aid of energy from the sun. But water is more than a nutrient; it is the medium for life.

## Lesson 5.7 Humans Are Part of Ecosystems

Organisms belonging to the same species live together. A group of organisms of the same species occupying a certain area at a given time is called a **population**. Thus, you hear of the human population in the Philippines in 1950, the population of *tamaraws* in Mindoro in 1983, or the population of mango trees in Bulacan in 1995. Note that the size of a population is defined in terms of its limits in space and in time.

Among the groups of populations on Earth, it is the human population that has increased at a rate far more rapidly than Earth can actually support. Do you know that there are now about 6 billion people in the world? Most developing countries have big population. It means that the density of people per unit area is high.

How can the density of the human population be determined? Take your class as an example. Suppose your classroom has a floor area of 48 square metres (m<sup>2</sup>) and there are 48 students in the class. What is the population density of your class? If you spread out the students, you will find out that there is one student for every 1 m<sup>2</sup> of space.

Population density may be computed by using the formula

$$\text{Density (D) of population} = \frac{\text{number (N) of individuals}}{\text{space (S) occupied}}$$

Therefore, density of population is the number of individuals per unit of space.

Q5.25 Go back to your data in Activity 5.1. Compute the population density of each of the organisms found in your 1 m<sup>2</sup> quadrat.

What you did is one method of determining the size of a population in a given area. Researchers conduct their population studies by identifying several sampling sites. An actual head count is made on all organisms occupying a particular sampling site. This is repeated in other sampling sites. The average count is made for all the sampling sites and then multiplied by the total area.

The population density of the human population is studied in a similar manner. Have you heard of census? Do you know why there is a need to take a random sampling of the population such as the nationwide census conducted every five years?

The population of the Philippines is given in Figure 5.11. From the data, you can compute for the population density in the country. Remember that the land area of the Philippines is 300 000 square kilometres.

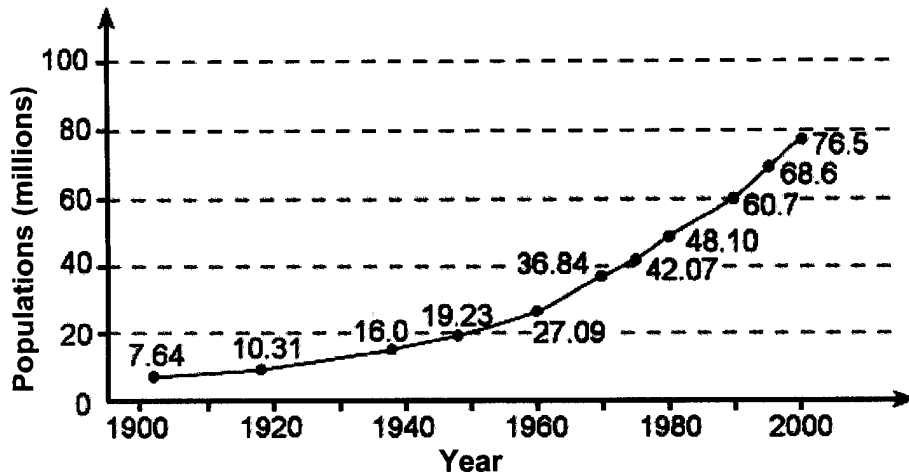


Figure 5.11 The Philippine population from 1900 to 2000

### Activity 5.3 Determining Population Density

#### Procedure

1. Study Figure 5.11.
2. Solve for the population density in the Philippines in 1900.
  - a. Repeat the same computation for years 1920, 1950, 1975, and 2000 respectively. What is the population density in the Philippines in those years?
  - b. How much is the increase in population from 1975 to 2000? Express this in percent.
  - c. Predict the effect of this increase in population on food supply assuming that production of food would be the same in 2003 as in 1990.
  - d. What natural calamities in the Philippines could possibly reduce food production?

Population experts reveal that on the average, three Filipinos are born every minute, while only one person dies. Thus, two Filipinos are added to the population every minute resulting in 2 880 more Filipinos daily or nearly 89 280 more monthly.

Science and technology contribute to the decrease in death rate. People now have longer life spans than 50 years ago. New medicines can prolong life. Early detection of diseases using sophisticated medical equipment saves people's lives. Good diet and proper exercise also make people healthy and free from illnesses.



The human population increases in an exponential manner. The following is an analogy which will help you understand what it means.

A farmer started with a few water hyacinths in a pond 128 square metres in area. These hyacinths double in number daily. During the first Sunday, the water hyacinths covered less than 1% (or  $1/128$ ) of the surface area, but he did not worry.

Still doubling in number, the hyacinths covered  $1/62$  of the water surface on Monday,  $1/32$  on Tuesday,  $1/16$  on Wednesday,  $1/8$  on Thursday, and  $1/4$  Friday. The following Sunday, the pond was completely filled with hyacinths. The full capacity of the pond was reached. Any further increases in number can no longer be accommodated by the pond. The hyacinths were rapidly using up the nutrients in the water.

The increasing number of hyacinths is analogous to the growth of population not only in the Philippines but all over the world. Exponential growth means that the population doubles every year.

## Lesson 5.8 Human Population and Natural Resources

The Earth as a whole is an ecosystem. Everything people need to survive comes from Earth itself. Food is grown on soil or harvested in water. Timber comes from the forests. Minerals are mined under the ground. In short, Earth is like a large storehouse of useful materials.

Materials removed from Earth and used by people are called **natural resources**. In Unit 4, you studied fossil fuels and other energy resources. These are examples of natural resources. Natural resources can be divided into renewable and nonrenewable resources. Renewable resources can be replaced by nature. Wood can be replaced by growing them. Water can be replaced through the water cycle. Soil is a renewable resource. New soil is formed on Earth everyday but soil formation is a very slow process. On the other hand, oil and coal is nonrenewable. Once used, they cannot be replaced.

### Land and Soil Resources

Look at a globe—a model of Earth. What percentage of Earth's surface is land? Can all this land be used for farming or for human settlement? Why or why not?

Q5.26 What are the other uses of land?

Q5.27 Organize the uses of land according to common characteristics.

With the growing population, farms are converted into cities and towns. Land is also needed for industry. If too much land is used for cities, there may not be enough left for farms. An increasing population requires an increase in food production. New and improved crop varieties are developed and new farming technologies are used. Land not suitable for farming is made fertile through irrigation.

To preserve limited land resources, land use must be carefully planned and managed. Different land areas must be used for the right purpose. Cities, towns, and factories must be built in areas with the least damage to the environment. Areas that produce good crops have to be left for farming. Recreational areas should be developed without destroying farmland and forests.

Q5.28 Examine closely Figure 5.12. Describe the arrangement of crops in the two illustrations.

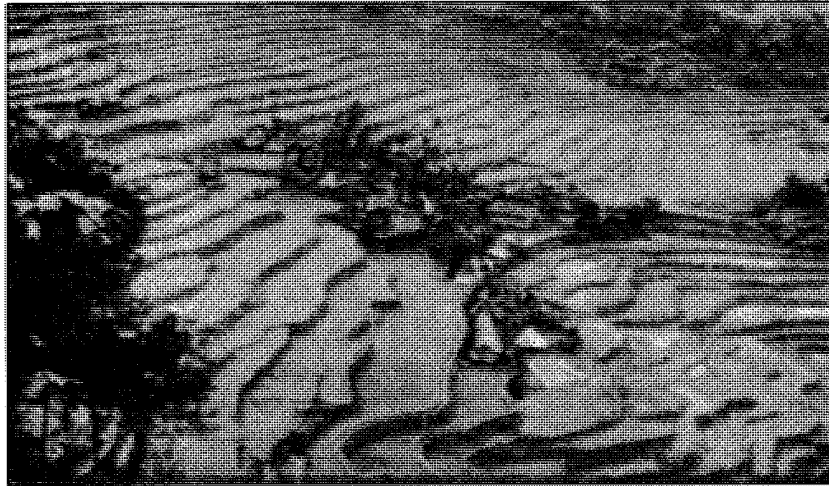


*Figure 5.12 Why are crops planted in these manner?*

Farming must be planned even more carefully should wide areas of land be used for this purpose. When one crop is grown on the same land for a long period of time, nutrients in the soil are depleted. Corn, for example, removes nitrogen from soil. Leguminous plants put back the nitrogen into the soil. Crop rotation must be practiced. For example, plant nitrogen-using crop for one year then nitrogen-producing crop for another year.

Contour plowing and strip cropping are also good land management practices. Contour plowing involves planting crops across the face of the slope of land while strip cropping involves planting strips of low cover crops between strips of other crops to hold the soil between other crops.

What happens if the topsoil is lost because of erosion? Did you know that it takes anywhere between 200 to 400 years for a centimetre of topsoil to be formed? Although erosion is a natural process, it is hastened by poor land management.



*Figure 5.13 Terracing, like contour plowing, slows down the runoff of water after heavy rains. Are you familiar with these rice terraces? This is one of the world's wonders and is found in Banawe, Mountain Province.*

Some land areas are dry. Only grasses grow on them. Most often, these areas are used for grazing animals. Overgrazing leaves topsoil exposed to wind. Dry grasslands become deserts and the process is called **desertification**. Many areas in parts of the world are in danger of desertification. Even in the Philippines some patches of deserts are found in Northern Luzon. Cutting down of trees for firewood may also bring about desertification.

Q5.29 What is the difference between renewable and nonrenewable resources?

Q5.30 What two farming methods help prevent soil erosion due to water runoff?

Q5.31 Why is it important to prevent overgrazing of grasslands?

Q5.32 Predict how an increase in human population will affect land use in the future.

## **Water Resources**

Three-fourths of Earth's surface is covered with water. This is the main reason why there is great variety of life forms on Earth or in areas where water is abundant. But why do we hear of people without drinking water or land areas suffering from drought?

Only a small percentage of this vast water is available for people to use. Seawater is salty for human consumption, for watering plants, or for direct use in industries. Many of the bodies of water are polluted. Although Earth's supply of freshwater is constantly renewed by means of the water cycle, there is limited supply of freshwater.

Most of Earth's freshwater resources are in soil as groundwater and frozen as ice in glaciers and ice caps. Humans get freshwater from rivers, lakes, and groundwater. Millions of litres of water are taken out of the ground daily. Groundwater is used up much faster than it is being replaced. As a result, the level of groundwater is dropping and many lakes and rivers are drying up. Wells are being drilled deeper and deeper as groundwater level drops. Places near the coastal areas suffer from saltwater intrusion because of too much pumping of freshwater from the ground.

Q5.33 How do you think saltwater enters the groundwater near coastal areas?

Do we have other sources of freshwater then? Scientists are looking at the ocean as a source of freshwater. **Desalination** is the process of removing salt from ocean water. Many countries in the Middle East depend on desalinated water for drinking. However, desalination is an expensive process.

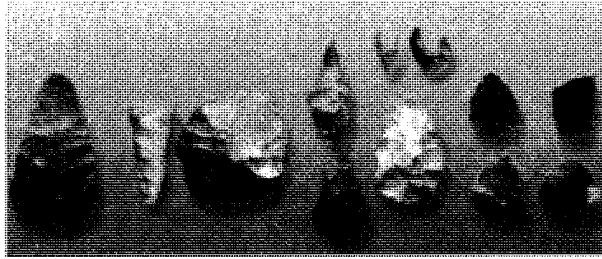
In order to have enough freshwater in the future, bodies of water must be prevented from getting polluted and harmful substances removed. The problem of water pollution will be discussed in Unit 8. Meanwhile, each one must learn how to use our limited freshwater supply wisely.

Q5.34 Some authors say that it is more correct to call our planet as "Water" rather than Earth. What do you think is the basis for this suggestion?

Q5.35 You must have heard the saying: "Water, water everywhere but not a drop to drink." When can this situation be true? Have you experienced something like this? Recount your experience through a drawing or short essay.

## Mineral Resources

People have used minerals even during ancient times to make tools for hunting food and later to grow crops. Have you heard about the Stone Age, the Iron Age, and the Bronze Age? These periods in human history were given these names to show the level of technology and extent of use of metals during those early times.



*Figure 5.14 Tools used during early times. These tools are made from minerals. What minerals do you know and where are they currently used?*

**Minerals** are naturally occurring chemical substances that are found in soil and rocks. Minerals are non-renewable resources. Why do you think are they considered non-renewable?

Minerals are mined or removed from Earth. Deposits of minerals are found as ores; they can be high-grade ore if the percentage of the mineral is high and low-grade ore if the percentage is low. Ores are found in many parts of the world. The Philippines has mineral deposits too. Do you know of any ores mined in your locality?

Earth contains many kinds of minerals. Iron is the most widely used metal extracted from metallic ores and used for making steel bars in combination with aluminum and carbon. Other metals include copper, used for electric wires and aluminum for cans. Gold and silver are used for jewelry. What other metals do we use in our daily lives?

#### **Home Activity**

Conduct a research on the minerals mined in your locality or province. Include a map to locate where these places are. What problems arise in these areas?

In Unit 6, you will learn more about minerals. For now you have to remember that the only way to mine most minerals, especially low-grade ore is through open-pit mining. Open-pit mining has disastrous effects on land and water ecosystems.

At this point, you can state the relationship between population and resources. This relationship is also described in terms of carrying capacity. A simple analogy will show this: A small boat can carry about five people. If you add two more people, the boat will be halfway submerged in the water. If you add two more, most probably the boat will already sink. The carrying capacity of the boat has been exceeded.

A certain place also has a carrying capacity. It can support only a given number of individuals at a given time. When the number of individuals is more than what the resources of that place can support, then the carrying capacity is exceeded. When there is plenty of food (a resource), population size may increase. There will come a time when the resources in that community cannot support the increasing population. Food becomes scarce and competition among individuals arises. Some die or simply move to other places where they can find more food.

Review the lessons on food chain and food web, nutrient cycling, and energy flow in ecosystems. These emphasize the principle of interconnectedness. The principle states that: Everything is connected to everything else. What one does affects others, directly or indirectly.



*Figure 5.15 This illustration shows different ecosystems from the mountain to the sea. Explain the principle of “interconnectedness” through this illustration.*

Lack of or inadequate food supply for the growing population gives rise to environmental problems. Forests are converted into agricultural lands. The conversion of forests into agricultural lands contributes to the destruction of watersheds from where local water supply comes. Shortage of water in turn reduces our capacity to supply energy or electricity from existing hydroelectric plants; thus increasing the cost of these services. The conversion of forest into tillable lands to increase food supply also causes soil erosion and wildlife destruction.

Overexploitation of the resources results in the destruction of the environment. Starvation, malnutrition, and other health deficiency cases become widespread especially in developing and underdeveloped countries. In most of these cases, scarcity of food is cited as the primary factor that created such problems on health maintenance and survival. You will learn more about environmental problems in the next units.

Lack of resources is one reason for the migration of people from rural to urban areas. Added to this is the perception that there are more opportunities for work and better education in big cities. These are not necessarily true because migration to cities creates an imbalance in the urban ecosystem.

- Q5.36 Do you think overpopulation is also a problem among plants and animals? If your answer is yes,
- give specific examples to support your idea.
  - how do farmers solve the problem?
  - what problems arise due to these activities?

Weather conditions, which include temperature, rainfall, humidity, and wind also affect population size. Natural phenomena like typhoons, flooding, earthquakes, and epidemics may change the population of a certain place. Environmental problems like water and air pollution brought about by human activities also affect the population size.

Natural phenomena are difficult to control. But people can reduce the impact or even avoid dangers brought about by these phenomena if they understand and prepare for the hazards. You will learn more about natural disasters in Unit 6.

Human activities that create imbalance in ecosystem can be prevented or minimized with the use of appropriate science and technology and the right attitude towards environmental protection and conservation.

## **Lesson 5.9 Maintaining the Balance in Nature**

You have studied the dependence of organisms for each other in terms of food and/or shelter. You also learned that plants and animals need elements to survive. For example, animals are dependent on plants for oxygen and food while plants are dependent on animals for carbon dioxide and the nutrient they pass on to soils when they die and decay. Maintaining the nutrient cycles, the water cycle, and other processes in nature will allow life forms to survive.

What is meant by the phrase “maintaining the balance in nature?”

Consider an aquarium—a man-made ecosystem. Animals thrive inside the aquarium because plants continually release oxygen when they make their own food in the presence of sunlight. In turn, plants utilize the carbon dioxide given off by animals when they exhale. Animal wastes fall and decay on the sand. This decaying matter provides the needed sources of elements (nutrients) for plant growth. As long as there is enough supply of oxygen, carbon dioxide, nutrients, the right

temperature, and sunlight inside the aquarium, these animals and plants will continue to thrive. The balance inside the aquarium is maintained.

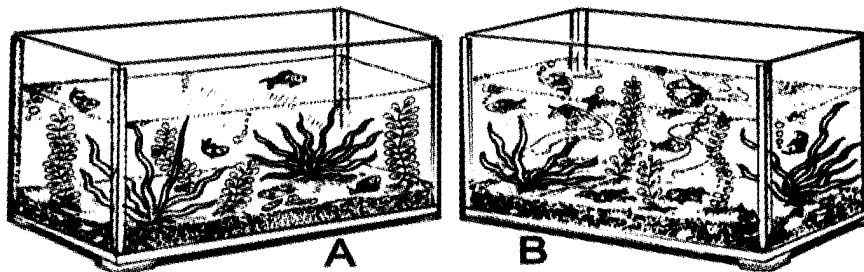
Q5.37 What will happen if there are more animals than plants inside the aquarium?

Q5.38 Why is it not good to put more food in the aquarium than what the animals actually consume?

### Activity 5.4 How Balance Is Destroyed in an Ecosystem

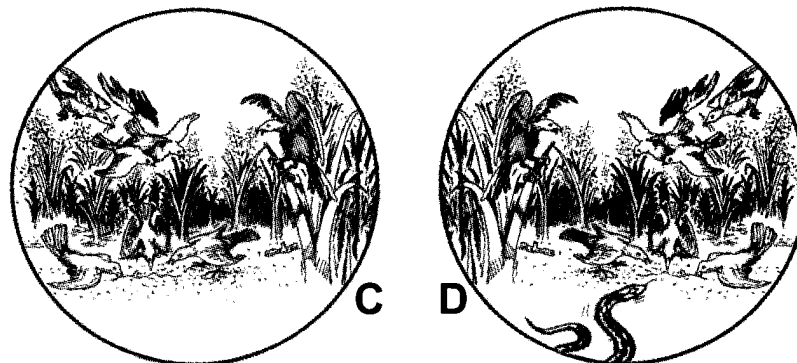
#### Procedure

1. Look at pictures A and B below.



- Describe what you see in Aquariums A and B.
- What are the chances of survival in Aquarium A?
- Why are there dead fish in Aquarium B?
- What are the chances of survival of the fish in Aquarium B?

2. Study pictures C and D.



- Describe what you see in Pictures C and D.
- What will happen to the rice plants if there are many birds?
- What will control the population of birds?



Pictures A and B emphasize how competition among organisms regulates the number of fishes. Competition also occurs in many fishponds which have become overpopulated. Fishes compete among themselves; predation, however, restores the biological balance in the pond.

Q5.39 If you were a fishpond owner, would you overstock your fishpond with fingerlings in the hope that you could produce more fish? Why? Why not?

Pictures C and D show that predation checks on the number of other organisms. Natural enemies are important parts of an ecosystem because they help restore the balance in nature. But if predation goes unchecked, the balance in nature will be disturbed.

## **SUMMARY**

Ecosystems are made up of living things (plants, animals, and decomposers) and nonliving things (water, air, soil, rocks, and sunlight). Ecosystems vary in size. They can be as small as a flowerpot or as large as Earth itself.

There are five main characteristics common to all ecosystems.

First, they contain different plants and animal species. Different species thrive in different ecosystems. Plants in the forests are different from plants in the grassland. Animals in the river are different from animals in the coastal areas.

Second, organisms interact with each other mainly for food. The transfer of energy from plant sources through a series of eating-and-being eaten stages is known as food chain. Food chains usually assume a simple linear form and seldom go beyond six stages. In nature, feeding relationships are complicated since most animals eat a variety of other organisms. When several food chains get linked with one another, they form a web. When one organism in the food web is totally removed or a new species is added, an imbalance in that ecosystem may occur.

Third, living things interact with their environment: There are three environmental conditions that dictate what species will survive in a certain place: climatic conditions (light, temperature, rainfall, and wind), soil conditions (nutrient content, moisture, and acidity), and topographic conditions (slope and altitude).

Fourth, energy flows in an ecosystem in a one-way direction—from the producer to the last level of consumer. This energy flow can be represented in a pyramid. Each consumer, regardless of the level it occupies in the pyramid, retains only about one-tenth of the energy of

what it has consumed. The remaining bulk of energy (9/10) is used up in the process of actual living. Therefore, any given amount of energy at the producer's level decreases as it is transferred from one level to the next. Very little of the original given energy reaches the top. The sun is the main source of energy.

Fifth, matter (nutrients) in the ecosystem goes through a cycle. Carbon, oxygen, nitrogen, sulfur, and other elements are passed on between the biotic and abiotic components of the biosphere. The water cycle was not discussed in this unit, not because it is considered unimportant but rather because it is more than a mere nutrient providing the medium for life. But as a cycle just like that of carbon and the others, water also circulates in the biosphere through the biotic and abiotic components with the aid of energy from the sun. Decomposers play a major role in nutrient recycling in the environment.

The Earth is a big ecosystem. The thin layer where living things are found is called the biosphere. All the natural resources humans need to survive—land, water, and minerals should be protected and properly managed to enable life to continue and survive on Earth.

Ecosystems are not made up of living things alone. These living things interact with each other and with the nonliving part of the environment. Even humans are part of an ecosystem. The human population has increased so rapidly that they are contributing more to the imbalance in the ecosystem than what natural phenomena bring.

Science and technology have contributed to the overpopulation and the problems it brought but people can play important roles in preserving the ecosystems. Concrete steps and actions can restore balance in nature.

## **SELF-TEST**

### **I. Multiple-Choice Items**

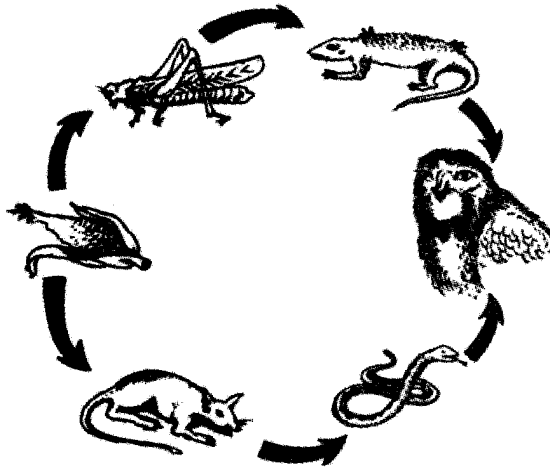
Choose the letter of the correct answer.

1. Which statement does not describe a producer?
  - a. It manufactures food.
  - b. It captures sunlight.
  - c. It absorbs carbon dioxide.
  - d. It breathes and excretes waste products.
  
2. Why is carbon dioxide important to living things?
  - a. It is a pure substance.
  - b. It is abundant in the environment.
  - c. It is used by plants in producing sugar and starch.
  - d. It is given off by animals when they break down food.

3. Why is oxygen regarded as the life-giving element on Earth?
  - a. It supports burning of materials.
  - b. It is 21% of Earth's atmosphere.
  - c. It is given off by plants.
  - d. It is needed for many chemical processes in the body.
4. Why is nitrogen essential to all living things?
  - a. It is needed to make proteins.
  - b. It is converted into nitrates.
  - c. It can be acted upon by bacteria in the soil.
  - d. It is the most abundant gas in the atmosphere.
5. Which statement best describes a food web?
  - a. Plants manufacture food.
  - b. All animals are flesh-eaters.
  - c. One animal eats another animal.
  - d. No living things can exist totally independent of other living things.

For items 6 to 9 refer to the diagram at the right.

6. The diagram represents a
  - a. food chain
  - b. food web
  - c. cycles of matter
  - d. energy of pyramid
7. Which is the producer in the diagram?
  - a. the rat
  - b. the corn
  - c. the grasshopper
  - d. the hawk
8. Which are the first-order consumers?
  - a. snails and hawk
  - b. rat and snails
  - c. grasshopper and rat
  - d. rat and hawk



9. What relationship is shown when the snake eats the rat?
  - a. predator-prey
  - b. parasite-host
  - c. competition
  - d. give and take

10. What will be the effect if mongo plants are placed back to the soil after harvesting the seeds?
  - a. Soil is loosened.
  - b. Plant is loosened.
  - c. Nonedible parts of plants are buried and disposed of.
  - d. Soil fertility is increased.
  
11. Which statement best describes a population?
  - a. It is composed of individuals of any kind.
  - b. It is composed of groups of different kinds of individuals in one area.
  - c. It is a group of individuals of the same kind in an area at a given time.
  - d. It is made up of all groups of organisms in an area at a given time.
  
12. Why is azolla a good substitute for commercial fertilizers?
  - a. It is easily grown and easily available.
  - b. It is easy to apply.
  - c. It is cheap and rich in nitrogen.
  - d. All of the above.
  
13. There are 20 mango trees per hectare of land in Sta. Maria, Bulacan. This statement describes
  - a. population growth
  - b. birth rate
  - c. death rate
  - d. population density

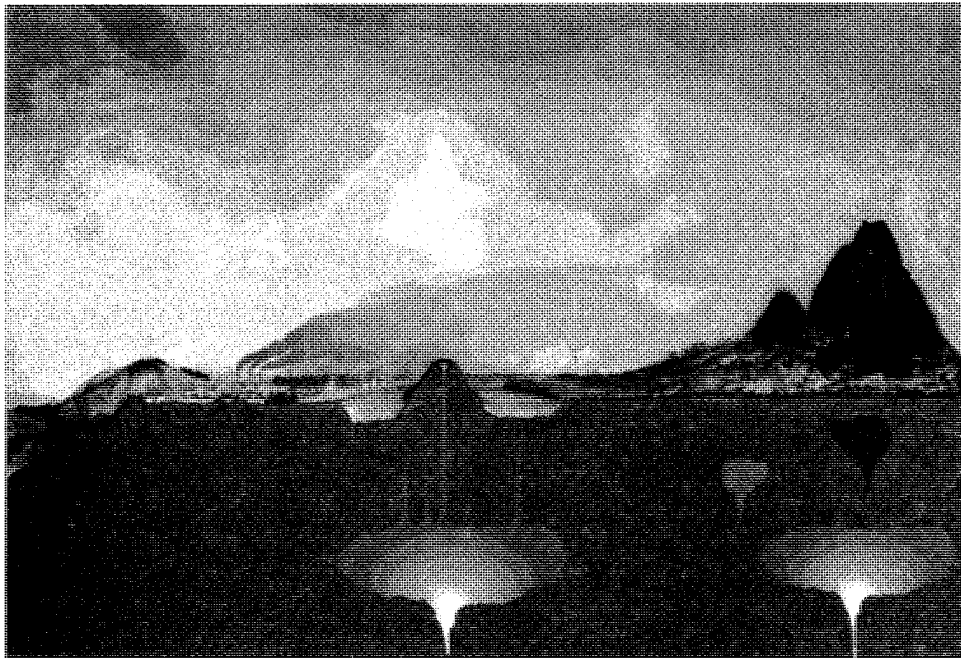
## II. Open-ended or Constructed - Response Items

Answer the following.

1. Consider this situation: A barangay is located near a creek. Most of the residents do not have sanitary toilets so they defecate on the water of the creek. In the beginning when there were few residents, nature spontaneously purified the water. Fish and other aquatic resources abound. Later, the population grew, but their habits remained. Now, the residents' source of food and livelihood are destroyed.  
What do you think will happen to the barangay in about 10 years from now if the unsanitary practices are continued? Give at least three changes.
  
2. Give two examples of your own activities which can upset the balance in nature. What do you think should be done to restore the balance in nature?
  
3. Is land a renewable resource? Why or why not?
  
4. Is water a renewable resource? Why or why not?

## Unit VI

### Changes in the Lithosphere



What if all of Earth's landmasses were connected with each other? Would it be more exciting since you can go places by land? Did you know that Earth's continents were once joined together? Earth is a dynamic system so that these continents are where they are now and are still continually moving.

You can see the proofs that Earth is dynamic. The Philippines is rocked by five earthquakes a day. Volcanoes throw out hot lava from inside the Earth while it rumbles. Mountain building and its subsequent wearing away sculpture Earth's surface.

## Lesson 6.1 Physical Features of Earth

Look around you. Which physical features of planet Earth can you see in your community? Can you see mountains and hills? What other physical features can you see? Why do you think there are mountains or volcanoes in one place but not in others?

The mountains in the Philippines are much smaller than those in some other parts of the world. Mt. Apo, the highest peak in the Philippines, is 2 954 m. The highest peak in the world, Mt. Everest in the Himalayas between Nepal and Tibet, is 8 848 m. Why are some mountains taller than the others?

Do Activity 6.1. Try to list down some physical features of Earth.

### Activity 6.1 Earth's Physical Features and the Philippines

#### Materials

relief globe or topographic world map  
Philippine geological map

#### Procedure

1. Examine a relief globe or topographic world map. Consider the following: (a) the shape and position of the continents, (b) patterns of mountain ranges and trenches (deep parts of the ocean usually near the landmasses), (c) other physical structures on Earth's surface (where the tallest mountains are, where volcanoes are found, etc.).
  - a. Compare the shapes of the facing coastlines or the eastern coastline of South America and the western coastline of Africa, the southeastern coastline of the United States and the northwestern coastline of Africa. If these were pieces of a jigsaw puzzle can you somehow fit them together?
  - b. Can you see mountain ranges near trenches? Give one example of such a pair.
  - c. Locate Nepal. This is where you can find the highest mountain range. What is this mountain range called?
2. Examine a Philippine geological map and draw its physical outline. Consider the following physical features: (A) the three major island groups; (B) location of the active volcanoes; (C) the Manila and Philippine Trenches; (D) the mountain ranges; and (E) the Philippine Fault

- d. The Philippine landmasses are surrounded by trenches and have many volcanoes and fault lines while there are many countries which do not have any of these. Do you think these physical features are interrelated?
- e. The Philippines is also frequently visited by earthquakes. Are earthquakes related to the physical features cited in question d?

Have you noticed that you can somehow fit the facing coastlines of South America and Africa with a little clockwise rotation of Africa? If you bring Africa near America, you can somehow fit the southeastern part of the United States and the northwestern part of Africa. Are the shapes of these landmasses related at all?

You can see mountain ranges that border the Pacific Ocean (called Circum-Pacific belt) and another runs through the Mediterranean eastward across the Middle East to the Himalayas and ends in the Celebes Sea, where it meets the Circum-Pacific belt. These mountain belts are also the earthquake and volcanic belts of Earth.

Mountain ranges are also found underwater as part of the ocean floor. They are called the oceanic ridges. Unlike the mountain ranges on land, the oceanic ridges are made mostly of volcanic rocks.

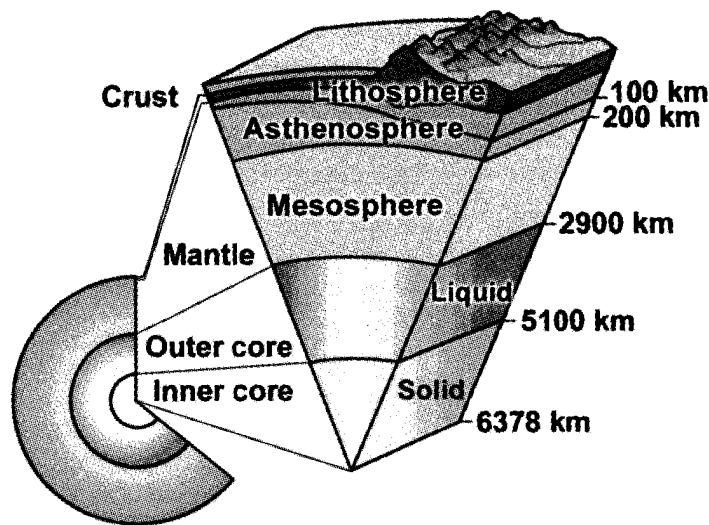
You will learn in this lesson that mountain ranges, trenches, volcanoes, and earthquakes are all related with each other. To understand this, let us first discuss Earth's internal structure.

## Layers of Earth

Earth can be pictured as consisting of a series of concentric layers (Figure 6.1), each layer being made up of materials with different compositions and densities (Table 6.1). In terms of composition the four Earth layers, beginning from the outermost are the crust, mantle, and the outer and inner cores. The estimated thickness of each layer is shown in the right portion of Figure 6.1.

**Table 6.1 Density and Composition of Each Earth Layer**

Layers	Density	Composition
Inner Core	About 12.9 g/cm <sup>3</sup>	Probably has iron and nickel and either in solid or dense liquid state
Outer Core	Similar to the inner core	Similar to the inner core but entirely liquid
Mantle	About 5.7 g/cm <sup>3</sup>	Iron-magnesium silicate materials
Crust	About 2.6 to 2.9 g/cm <sup>3</sup>	Oceanic crust: rich in iron and magnesium Continental crust: relatively rich in potassium



*Figure 6.1 Layers of Earth. In terms of composition: inner and outer cores, mantle, and crust. In terms of physical properties: inner and outer cores, mesosphere, asthenosphere, and lithosphere (USGS, modified)*

The crust beneath oceans is about 10 km thick while the crust in continental areas varies in thickness ranging from around 35 km to 70 km.

Pressure and temperature within the different Earth layers increase with depth. Pressure and temperature determine the physical properties of Earth's layers.

The mantle, because of its thickness, has three different layers based on physical properties:

- a. The upper portion of the mantle is much cooler, rigid, and brittle. Having similar physical properties as the crust, this upper mantle and the crust together form the **lithosphere**.
- b. The **asthenosphere** is the next layer within the mantle. The rocks in this layer are weak and get easily deformed, like butter or warm tar. It is composed of partially molten slush-like rock material consisting of solid particles with liquid occupying spaces in between. Although thin, the mobility of this layer allows the overlying lithosphere to move.
- c. The lower part of the mantle where rock is very highly compressed is called the **mesosphere**. The pressure in the mesosphere is so great that even though the rock is hot, it is solid and considerably more rigid than the rock on top of it.

From the outermost layer and in terms of physical properties, the different Earth layers are the lithosphere, asthenosphere, mesosphere, and the outer and inner cores.



## Lesson 6.2 Continental Drift, Seafloor Spreading, and Plate Tectonics

### Continental Drift

According to Alfred Wegener, the proponent of continental drift, the continents we know today had once been joined together in a single "supercontinent" which he called Pangaea. This giant landmass had later split into fragments (the continents of today) which slowly drifted across the surface of Earth.

How did the continents move apart? Scientists believe that North America drifted toward the northwest. Eurasia turned 20° clockwise as it moved northward. Africa and South America broke apart, forming the Atlantic Ocean. Africa turned counterclockwise and moved eastward, while South America moved westward. India separated from Antarctica and Africa, and then moved northeastward. Then India collided with Asia. Australia, once joined to Antarctica, broke off and drifted eastward. Since the continents are still drifting apart, their positions will be different millions of years from now.

The lines of evidence that support this idea are as follows:

- The facing coastlines of Africa and South America reasonably match;
- The fossils found along the matching coastline are similar (Figure 6.2);
- Geologic features such as mountain ranges and faults from separate continents line up along the matching coastlines;
- The type and age of rocks along the matching coastlines are similar;

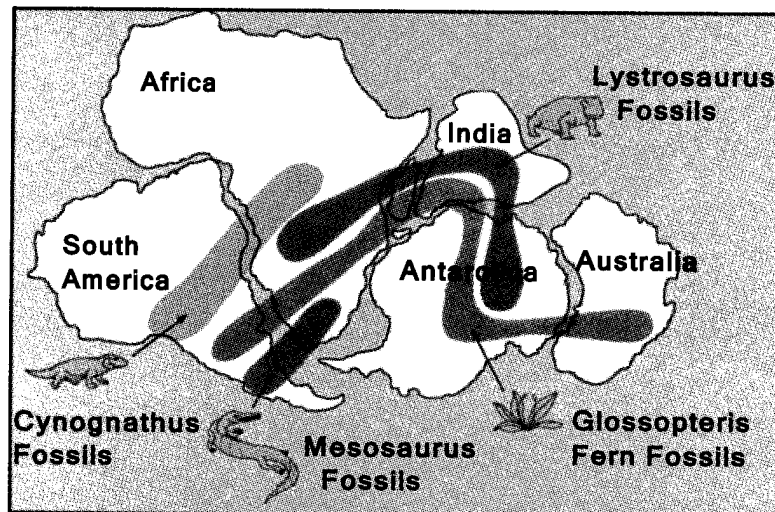


Figure 6.2 The continents were once joined as shown. The fossils of ancient animals and plants could be seen in different continents as indicated by the thick solid curved lines. (USGS, modified)

- Layers of coal in Antarctica indicate that it was once closer to the tropics;
- Deposits of glaciers match along the continental coastlines; the direction of ice movement is also consistent.

Wegener, however, could not adequately explain how the continents drifted so continental drift was not popularly accepted in his days.

## Seafloor Spreading

According to Harry Hess, a geologist from Princeton University, the seafloor is in motion. His statement was based on explorers' observations of the ocean floor in the 1950s to 1960s. Long mountain ranges, later called **oceanic ridges**, were found winding across the floor of all the oceans of the world. It was found that at the crest of each ridge was a deep linear valley showing signs of volcanic activity. It was observed that rocks near the oceanic ridge were much younger than those far from it. In fact, the age of rocks on the ocean floor increases as the distance from the ridge increases. Near the land, trenches (at this point we will just describe trench as a great depression in the ocean floor) were found and earthquakes were associated with them.

Hess said that the motion of the seafloor is due to the movement in the mantle beneath the seafloor. Hess, however, could not give proofs to his hypothesis.

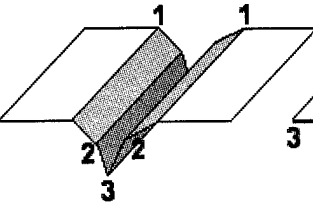
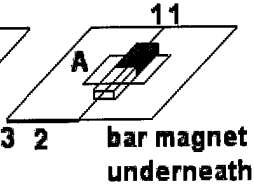
### Evidence that Supports the Seafloor Spreading

In 1963, Frederick Vine and Drummond Matthews of the University of Cambridge studied the magnetic properties of the ocean floor, which later gave proof to Hess' hypothesis. To understand their claim, first do Activity 6.2.

**Activity 6.2 Magnetic Stripe Simulation**

**Materials**

- 2 pieces of bond paper
- iron filings or iron sand
- bar magnet
- pencil

**Procedure**

1. Fold a bond paper into two and the inner half into two so that when you open it, it will be similar to Figure a above. Do the same thing for the second piece of bond paper.

2. Bring folds "1" of each paper together. Lay one paper flat on the bar magnet as shown in Figure b. You may use cardboard to support the bond paper. Sprinkle iron filings or iron sand on the bond paper.
  - a. What pattern can you see? Why do you think the iron filings or iron sand form a pattern? Recall Activity 4.2, step 5.
  - b. On the second paper still folded as the first one, draw the pattern you see. Just draw the pattern formed by the iron filings within 2 cm from the edge of the magnet and near its center. This region is within Area A as shown in the second figure above. Label the magnetic field pattern on each side of the fold, "magnetic stripe 1."
  - c. Carefully pull the paper folds "1" apart so that folds "2" will be together. Do this also for the paper on which you are recording your observation. Repeat steps 2 and 3. Label magnetic stripes 2.
  - d. Again pull folds "2" apart and lay the bond paper with its fold "3" over the magnet. Repeat steps 2 and 3.
  - e. Now open the paper on which you recorded your observation.
    - b. How many magnetic stripes are formed on each side of the magnet?
    - c. Compare the relative time the magnetic stripes were formed. Arrange from most recent to oldest.

The valley at the center of an oceanic ridge is characterized by volcanic activity. As lava comes out at the vent, one of the minerals that is formed is magnetite. Earth is a giant magnet so that it aligns the magnetite particles in patterns similar to your activity. When the lava cools and solidifies, the magnetic pattern is preserved. These are the magnetic stripes detected on the ocean floor (Figure 6.3).

At the crest of an oceanic ridge, new oceanic crust forms continuously, cools, and becomes increasingly older as it moves away from the ridge crest with seafloor spreading. In your activity, the fold represents the ridge. Note that the magnetic stripes that you formed are symmetrical relative to the ridge and those that formed earlier are farther from the ridge. This is also true in the ocean floor. The rocks are older when these are found farther from the ridge.

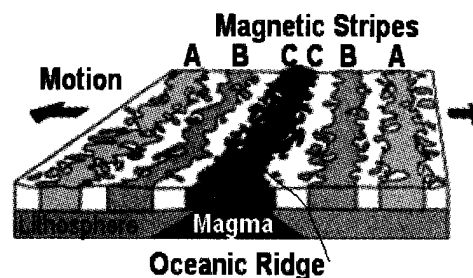


Figure 6.3 Magnetic stripes on the ocean floor (USGS, modified)

## Plate Tectonics

With the evidence given to support seafloor spreading, scientists were convinced that the surface of Earth is really moving. A theory, the Plate Tectonics Theory, was formulated to explain the drifting of the continents and the spreading of the seafloor. This theory states that the outermost rigid layer of Earth (lithosphere) is broken into several fragments called plates. See Figure 6.4. These plates are continually moving relative to one another as they ride atop hotter, more mobile materials of the asthenosphere.

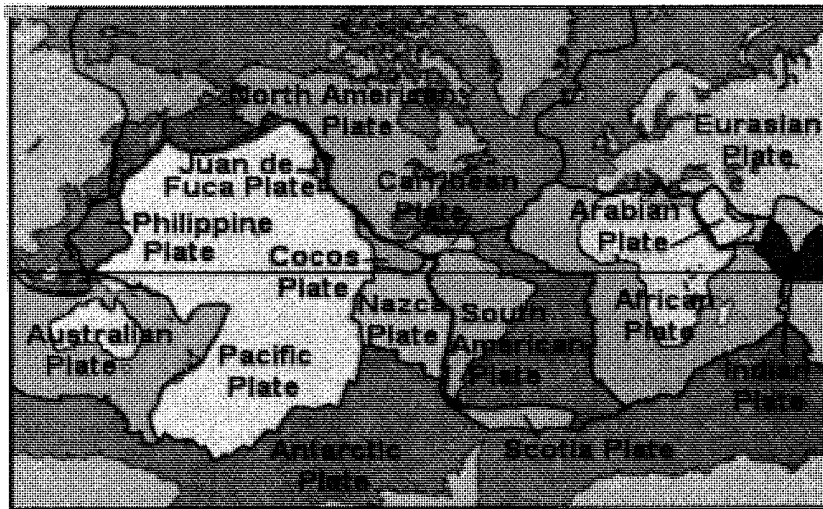


Figure 6.4 The lithospheric plates

What makes the plates move? The interior of Earth is hot. The heat is not distributed uniformly. Some places are very hot while others are relatively cooler. The hot rock materials within the asthenosphere rise because they are less dense and mobile. Cooler thus denser rock materials sink. (Refer to Figure 4.26). This rising and sinking of rock materials create movement inside Earth called **convection currents**. See Figure 6.5. It is this movement that drives the plates in motion.

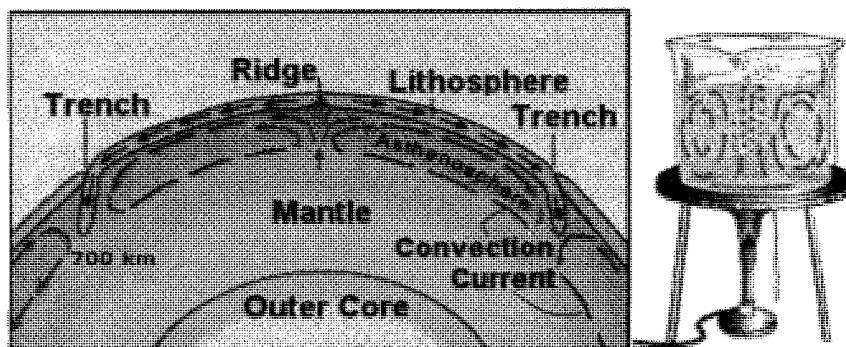


Figure 6.5 Convection currents in the asthenosphere move lithosphere

The upwelling of mantle materials along the oceanic ridge creates new seafloor. The convection motion of mantle material carries the seafloor in a conveyor-belt fashion to the very deep-ocean trenches, where the seafloor descends into the mantle.

Earth's plates move relative to each other in several ways as shown in Figure 6.6:

- Slide past each other in *transform boundaries*.
- Away from each other in *divergent boundaries* (where the lithosphere is being pulled apart).
- Toward each other in *convergent boundaries* where plates collide.

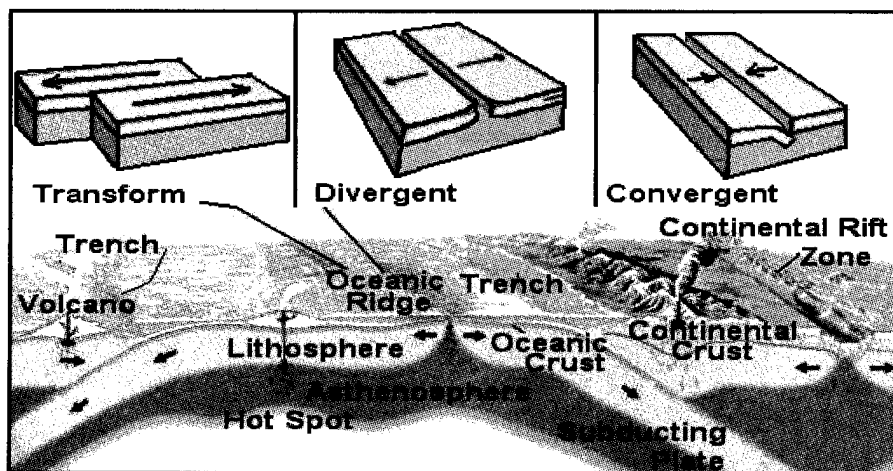


Figure 6.6 The different plate boundaries (USGS, modified)

As two plates collide the following scenarios may happen:

- Two continental plates in collision* - the rocks that are caught in between are squeezed, crumpled, and lifted (Figure 6.7a). In the process, mountains are built like the Himalayan Range north of India.
- Two oceanic plates in collision* - one of the plates dives under the other (Figure 6.7b). This process is called **subduction**. The diving plate will eventually reach a place inside Earth where melting occurs. The molten material, called magma will then rise to Earth's surface to form volcanic islands, such as the Marianas, Philippines, and Indonesia. These volcanic islands are always accompanied by trenches. A **trench** is a depression in the ocean floor where one plate is subducting under another plate. Hence, there is the Marianas Trench (east of the Marianas), Philippine Trench (east of the Philippines), and Java Trench (south of Indonesia). The Philippines is an island arc.
- Oceanic and continental plates in collision* - the oceanic plate (being the denser plate) subducts or dives under the continental plate (Figure 6.7c). The subduction will produce a trench and initiate volcanism.

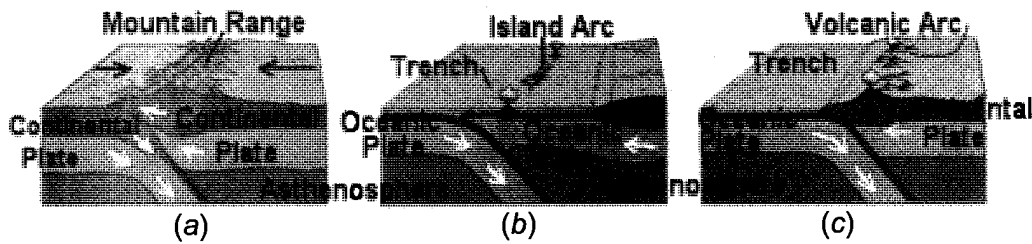


Figure 6.7 Scenarios at the boundaries of colliding plates: (a) two continental plates; (b) two oceanic plates; and (c) an oceanic and a continental plate (USGS, modified)

Do Activity 6.3 to test your understanding of the discussions above.

### Activity 6.3 Seafloor Spreading and Plate Tectonics

#### Materials

globe (preferably relief globe at least 30 cm in diameter) or bathymetric map  
chalk or pencil

#### Procedure

1. In your globe or map, find the areas on the ocean floor that may represent oceanic ridges. Draw two small arrows facing away from each other on the oceanic ridges. Draw two parallel lines on each side of the oceanic ridge and label the line nearer the ridge, A and the one farther, B.
  - a. Are oceanic ridges symmetrically positioned between continents?
  - b. What type of boundary do you find at the oceanic ridge?
  - c. In what line, A or B, are the rocks younger?
2. There may be areas where the oceanic ridges do not form a continuous line. Find these offsets and mark them on your map.
  - d. What type of boundary are those offsets called?
3. On the globe, locate the position of the deep trenches that border the continents. Some of these are found with a little distance from the continents and many are adjacent to islands. Mark the position of the trenches. Draw small arrows facing each other at these boundaries.
  - e. What do you call those boundaries at the trenches? Is there a trench near the Philippines?

4. The oceanic ridges, trenches, and transform boundaries form the tectonic plate boundaries. Using the map draw the position of the boundaries of some plates.
  - f. In general, do plate boundaries coincide with continental shorelines?
  - g. How many plates have you drawn?
  - h. Are there plates that contain both continents and oceans?
  - i. Are there plates that contain continents only? Oceans only?
  
5. Mark the boundaries of the Philippine plate and locate where the islands of the Philippines are.
  - j. Is the Philippine plate small, medium, or large? Why do you say so?

- Q6.1 What are the physical features of Earth that are brought about by the movement of plates?
- Q6.2 What is the effect of the movement of plates on the evolution and diversity of living things?

## Lesson 6.3 Mountains, Volcanoes, and Earthquakes

### Mountains

Remains of plants and animals, known to have been deposited on sea bottoms, have been found in many mountains thousands of metres high. Corals and sea shells are found in some rocks in Baguio. Leaf imprints of trees known to grow in the lowlands are found in Sagada, Bontoc. Could these mountains have been lowlands and sea bottoms millions of years ago? How are mountains formed?

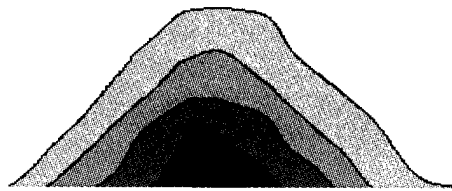


Figure 6.8 Crumpled layers of rock

Road cuts on the sides of some mountains have shown crumpled layers of rocks. Look at Figure 6.8. Why do some mountains have that kind of structure? It was mentioned in the previous lesson that the Himalayan Mountain Range is being created by the collision of two continental plates. Activity 6.4 will help you understand how this is so.

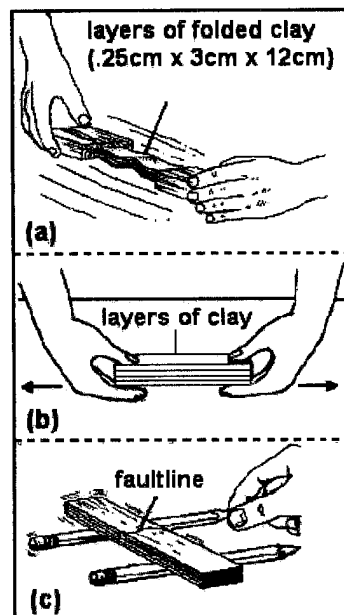
## Activity 6.4 Mountain Building

### Materials

big jar of clay soil	3 rulers	paper
2 blocks of wood	2 pencils	

### Procedure

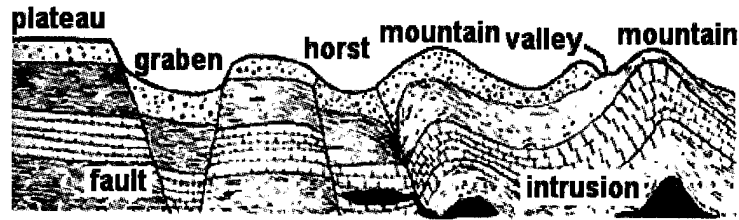
- Wet the clay. On a piece of paper, flatten the wet clay with the palm of your hand. Cut the clay into eight strips. Each strip should be about 0.25 cm thick, 3 cm wide, and 12 cm long. Put 4 strips one on top of the other (Figure a). Place a block of wood at each end. Slowly push the two blocks together. Set the clay strips aside. Let them dry and harden.
  - What happens to the clay strips as they are pushed from opposite ends?
  - Compare the length of the clay strips before and after pushing. What happens to the upward curve as you continue to push the clay strips? What happens with the downward curve?
  - Let the strips of clay represent Earth's crust. What does the upward curve represent on Earth's crust? The downward curve?
- Put the four remaining clay strips one on top of the other. Pull these strips apart as shown in Figure b.
  - What happens to the clay strips?
- Cut the strips into two as in Figure c. Call the line on the surface where the clay is cut, its fault line. Put the clay strips on two pencils. Slightly move one pencil up and down.
  - What happens to the clay strips when the pencils are moved?



Great forces from several directions act on the lithosphere, causing it to move. The movement is usually so slow that we can hardly detect it. But sometimes the movement is so sudden that we feel a shaking of the earth's surface known to us as an earthquake. You will learn more about earthquakes later in this lesson.



How do these forces affect the lithosphere? Although solid, Earth's lithosphere may be pushed or pulled out of shape by great forces exerted on it over long periods of time. When a part of the lithosphere is pushed from opposite directions it crumples, bending upward and downward. This process is called **folding**. The upward curves form mountains (Figure 6.9). The downward curves form valleys. The Sierra Madre in Luzon is an example of a folded mountain.



*Figure 6.9 Land features resulting from plate movement*

Mountains may form in another way. Pushes from the magma below moving up and filling in spaces between rock layers may cause the surface to bulge, forming hills or mountains. The process is known as intrusion. The Cordillera Mountains in Luzon were created more by intrusion rather than folding, with the Agno Batholith at its core.

Unequal pulls and pushes on the lithosphere from different directions may become greater than the elastic limit of the rocks. Large cracks may form. Continued pulling and pushing, lengthen and widen the cracks, forming faults. Rock layers may slip and slide along these faults. A block of rock between two faults may sink, forming a **graben**. In time, erosion may smooth out the vertical walls of the sunken area and make it look like a valley. The Marikina Valley is a graben caused by downward movement of the middle part. The Dead Sea, now filled with very salty water, is the best known example of a sunken area between two faults. The rising or sinking of rock masses along a fault is described as vertical movement.

A block of rock between two faults may rise forming a horst. Sometimes the rock layers move horizontally along a fault, with little or no sinking or rising on either side. Horizontal movements in the Philippine fault zone are known to have occurred. Sudden horizontal and vertical movements of rock masses along faults are felt by people as earthquake.

The lithosphere of Earth in continents and islands as well as at the ocean bottom has many cracks and faults. The Philippines has many faults. One of them is a major fault that runs northwest to southeast across the country. The side west of the major fault shows a southward movement, while the east side shows a northward movement (figure in Activity 6.5).

## Volcanoes

What are volcanoes? How is a volcano different from a mountain? How are volcanoes formed? Are the locations of volcanoes related to earthquake belts?

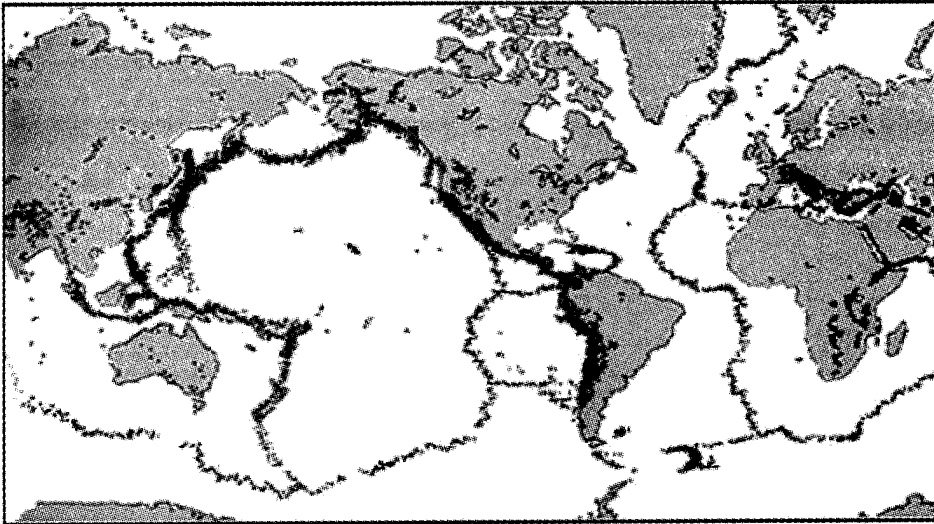


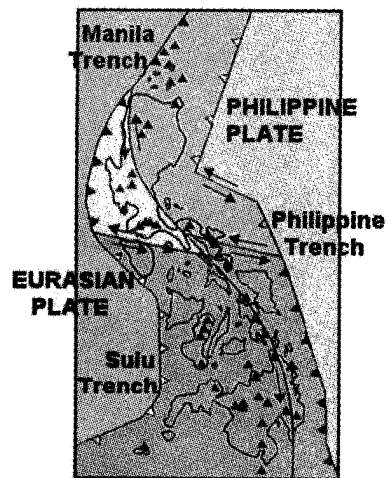
Figure 6.10 Distribution of earthquakes (dark dots) around the world (USGS)

### Activity 6.5 Earthquakes, Volcanoes, and Plate Tectonics

#### Procedure

1. Compare the map of the plate boundaries in Figure 6.4 with the earthquake map of the world in Figure 6.10.
  - a. Relate the position of the plate boundaries (Figure 6.4) and the earthquakes (Figure 6.10).
  - b. Compare the frequency of earthquakes in convergent, divergent, and transform boundaries. Which type of plate boundary shows the most defined concentration of earthquakes?
2. The Ring of Fire, also called the Circum-Pacific belt, is the zone of earthquakes surrounding the Pacific Ocean. About 90% of the world's earthquakes occur there.
  - c. Where is the Philippines in relation to the Ring of Fire?
3. Mark the Philippine plate on your earthquake map. Encircle the Philippine islands.

- d. Where do you find the Philippine group of islands? Is it at the center of the Philippine plate or at its edge?
- e. What does your earthquake map reveal about the frequency of earthquakes in the Philippines? Why do you think that is so?
- f. Why does the Philippines experience frequent earthquakes?

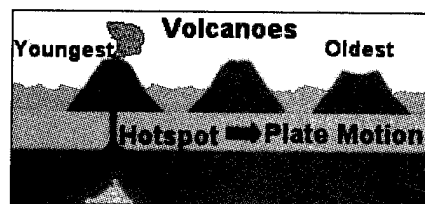


*The distribution of volcanoes in the Philippines (isolated triangles)*

4. Study the figure which shows the distribution of volcanoes and the position of the oceanic trenches around the Philippines.
  - g. There are about 220 volcanoes in the Philippines. Identify and locate some of its known Philippine volcanoes. Why does the country have many volcanoes?
  - h. How do the locations of the volcanoes relate to the trenches?
  - i. Are the presence and locations of the volcanoes related to plate tectonics? Why do you say so?

Earthquake occurrences are usually more frequent along convergent than on divergent boundaries.

Most of the volcanoes of the world too are found near plate boundaries. Seventy-five percent of the world's active volcanoes are located above the subduction zones at the convergent boundaries like those at the Circum-Pacific belt. The ocean ridges along divergent boundaries are in fact long ranges of volcanoes. There are volcanoes though which are not found on plate boundaries like those in Hawaii. These are formed by hotspots. **Hotspots** are rising plumes of magma pushing their way through the mantle to the Earth's surface. Once the magma reaches the surface it makes the hotspot visible in the form of volcanoes (Figure 6.11) or hot springs. Over time the overriding plate over the permanent hotspot moves and a new volcano is created. The old volcano, no longer over the hotspot, becomes extinct. This process keeps



*Figure 6.11 Hotspots form volcanoes*

on repeating itself until there is a chain of volcanic islands created by the same hotspot. Only the most recent volcano is active, the others have become extinct.

The Philippines is in a tectonically active region, it being along the boundary of a small plate, the Philippine plate and along the Circum-Pacific belt or Ring of Fire. The Ring of Fire is the most seismically and volcanically active zone in the world. Why is this so?

Can we correlate the occurrences of earthquakes in the Philippines to the trenches around it? The trenches are due to subducting plates. Earthquakes are produced as the subducting lithospheric slab moves. More shallow earthquakes are found nearer the trench and deeper ones farther from the trench.

Volcanoes found in the Philippines are due to subducting plates. As a lithospheric slab is being subducted, the slab releases volatiles that rise upward. Because of this, rocks above the subducting slab melt. The molten material rises and leaks into the crust (Figure 6.12), forming a series of volcanoes. These volcanoes can make a chain of islands called an island arc. The Philippines is an island arc. Island arcs are formed on the plate above a subducting slab. For each case, there is an associated subducting slab and a trench.

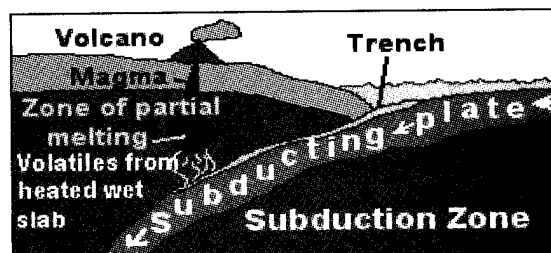


Figure 6.12 Subducting plate creates volcanoes

- Q6.3 Examine the figure in Activity 6.5. Identify the subducting plate that produced the Philippine Island Arc.
- Q6.4 Refer to a Philippine map. Where do you think deeper earthquakes are likely to occur—in Surigao del Sur or in Davao? Explain your answer.
- Q6.5 Consider Mt. Pinatubo and Taal Volcano. Which subducting plate do you think produced them? Which subducting plate caused Mts. Mayon and Bulusan? Why do you say so?
- Q6.6 What natural phenomenon or land features mark the boundaries of plates?

Which Philippine volcano erupted recently? What happens during a volcanic eruption? Have you heard of the effects of Mt. Pinatubo when it erupted in 1991 (Figure 6.13) after being silent for more than 600 years? The ashes it emitted affected not only the Philippines but the entire globe. Visibility was reduced and airline flights were cancelled. Many places in Zambales and Pampanga were buried under **lahars**. These are deposits made of materials that came out of the volcano mixed with water. Some

of its ashes reached the stratosphere and circled around the globe, blocking some sunlight and affected the climate for more than 10 years.



*Figure 6.13 Mt. Pinatubo eruption in 1991*

From afar, a volcano looks like an ordinary mountain. However, it has a vent where molten rocks from the magma chamber pass through as these move towards the opening or the crater. Magma that goes out of the crater is called **lava**. Pyroclastic materials, fine solid particles, and gaseous materials are also emitted from an erupting volcano.

### **Volcanic Eruption**

Why do volcanoes erupt? In the Earth's mantle, temperatures are hot enough to melt rock and form a thick, flowing substance called **magma**. Magma is less dense than the solid rock that surrounds it so that it rises. As the magma rises, some of it collects in magma chambers. Eventually some of the magma pushes through vents and fissures in Earth's surface. As it comes nearer Earth's surface, pressure decreases which causes the gas bubbles in the magma to expand. Having bigger gas bubbles, the density of the magma is reduced even more, resulting to its faster ascent that leads to volcanic eruption. Once magma is spewed out of a volcano, it is called lava.

Different volcanoes erupt in different ways—some are explosive, others are not. The way a particular volcano erupts is influenced by many factors, but the most important ones are the **viscosity** (the ability of a substance to resist flowing) and gas content of the magma. The most abundant gases in magma are water vapor, carbon dioxide, sulfur dioxide, and hydrogen sulfide (the rotten egg smell that fills the air in the vicinity of volcanoes). Magma with low gas content produces a gentle eruption. Magma with high gas content either produces an explosive or gentle eruption depending on its viscosity. If it has a low viscosity, the gas can easily escape from the rising magma and hence does not produce an explosive eruption. But if the magma is highly viscous, the gas cannot easily escape so that pressure slowly builds up until the strength of the magma is overcome. The magma is then shattered into pieces by the

escaping gases. The result is an explosive pyroclastic eruption (fragmentation of the magma) just like the eruption of Mount Pinatubo in 1991.

Mayon Volcano attracts many viewers when it erupts because of the beauty that it exudes. But volcanic eruption is accompanied by some hazards. What are some of these? In an explosive eruption, the magma is shattered into bits and pieces, forming pyroclastic fragments that fall all around the volcano, covering and even scorching its slopes and surrounding areas with its hot fragments. This endangers the people living in the area, not only by being hit by the hot fragments but also by inhaling toxic gases and particulates from the volcano. There were thousands of houses that were buried due to the eruption of Mt. Pinatubo. There were also buildings that collapsed because of the weight of the volcanic materials deposited on the roofs.



*Figure 6.14 Mt. Mayon eruption and its effects  
(<http://www.educeth.ch/stromboli/others/mayon/mayon00-en.html>)*

In explosive types of eruption, very hot pyroclastic fragments travel very fast down the slopes of the volcano and can travel long distances. A lava flow that is slow enough for people to outrun is still destructive. Lavas cannot be stopped and they bury everything along their way. They harden like cement so it is impossible to unearth a barangay under solid lava. They can be as hot as 1 000 °C and can ignite combustible materials along their path. Pyroclastic materials deposited on the slopes of a volcano when saturated with water (rain, streams, or lakes) become heavy and flow down as lahar. Lahars can be as thick as wet concrete so that they can easily transport huge boulders downstream. They can travel as fast as 10 m/s and can be as hot as 100 °C. A person who gets caught in lahar will be boiled alive and crushed between colliding

boulders. For about six years, lahars resulting from the Mt. Pinatubo eruption threatened communities near the volcano during rainy seasons. Volcanic gases can cause suffocation, too.

### Volcanoes in the Philippines

Listed in Table 6.2 are active volcanoes in the Philippines. Study the table. Are there active volcanoes in your region? Name them. Which region has the highest number of active volcanoes? Identify the trench near areas where there are active volcanoes. Why do you think are there no volcanoes in Palawan?

**Table 6.2 Active Volcanoes in the Philippines**

Name of Volcano	Latest Eruption Date	Location	Name of Volcano	Latest Eruption Date	Location
Mayon	2003	Albay	Cagua	1860	Cagayan
Taal	1977	Batangas	Banahaw	1730	Lucena City
Canlaon	2003	Negros Or.	Calayo	1886	Bukidnon
Bulusan	2006	Sorsogon	Iraya	1464	Batanes
Ragang	1915	Cotabato	Pinatubo	1991	Zambales
Hibok-hibok	1953	Camiguin	Iriga	1641	Camarines Sur
Didicas	1978	Babuyan Islands	Bud Dajo	1897	Lolo Island
Babuyan Claro	1924		Matutum	1911	Cotabato
Camiguin de Babuyan	1957		Biliran	1939	Leyte
			Parker	1641	South Cotabato

Now that you have learned that there are hazards accompanying volcanic eruption, if there is volcano near your place, you need to watch out and be prepared.

### What to Do During Volcanic Eruption

The following are some indicators that a volcano is about to erupt:

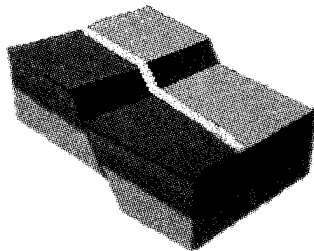
- More frequent earthquakes in the area;
- Bulging of some parts of the volcano;
- Increase in the temperature of the surrounding area, especially water in springs;
- Withering of plants and vegetation around the volcano;
- Changes in the acidity and composition of water in the hot springs; and
- Increase in the size of cracks where gases are emitted.

## Minimizing Harmful Effects of Volcanic Hazards

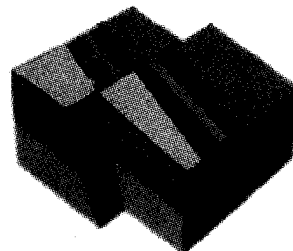
- Do not live near an active volcano. PHIVOLCS (Philippine Volcanology and Seismology) has declared permanent danger zones, about 4 to 6 kilometres from the summit of several active volcanoes (Mayon, Taal, Canlaon, Bulusan, Hibok-Hibok, Pinatubo). These are areas where people are prohibited from putting up permanent settlements.
- Despite the restriction, many people choose to live in the shadow of a volcano because of the fertile soil that is available for farming. If you happen to be with these families, consult a hazard map which shows the areas around an active volcano where the different hazards are most likely to take place.
- During an eruption, leave the permanent danger zone immediately. Stay away from the valleys and avoid all places indicated as dangerous in the hazard map. Cover your nose with a wet piece of cloth to avoid inhaling volcanic ash and gases. Outside of the danger zone, houses and buildings may be prevented from collapsing by continuously shoveling off the pyroclastic debris accumulating on the roof tops.
- Always be on the alert for warnings of further volcanic unrest issued by PHIVOLCS and other government agencies.

## Earthquakes

Earthquakes are caused by the movement of plates (tectonic earthquakes) and by the eruption of volcanoes (volcanic earthquakes).



(a) *Dip-Slip Fault*—This occurs when rocks along one side of a faultline move vertically. Cliffs are common physical land features which result from a normal fault.



(b) *Strike-Slip Fault*—A strike-slip fault is formed when rocks along one side of the fault move horizontally along the faultline.

Figure 6.15 The two major types of faults

The Philippine archipelago is situated in the collision zone of the Eurasian plate subducting in the west and the Philippine Sea plate



subducting in the east. The oblique convergence of the Eurasian and Philippine Sea plates (Activity 6.5 figure) leads to the development of the Philippine Fault System and other smaller shallow crustal faults.

There are two major types of faults: the dip-slip fault and the strike-slip fault. These are illustrated and described in Figure 6.15.

The Philippine Fault System is a major strike-slip fault structure that traverses the entire length of the archipelago and has produced minor faults (Figure 6.16). Several of the most destructive earthquakes in recorded history, including the 1990 Luzon earthquake, came from the movement of the Philippine fault.

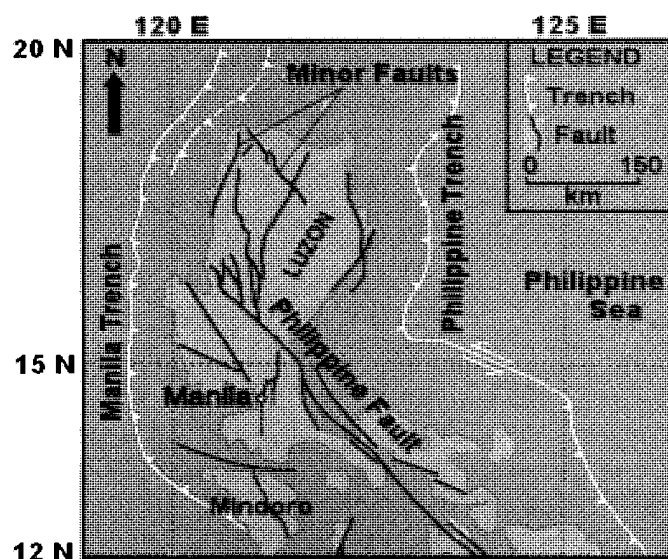


Figure 6.16 The Philippine and minor faults from Luzon to mid-Visayas

When does an earthquake occur? As two plates move relative to each other, stress is built up between them. If friction along the fault prevents gradual movement, the stress will build up until sudden slippage occurs along the fault. This is an earthquake. The point along a fault where movement first occurs is called the earthquake's **focus** (Figure 6.17). The point on the earth's surface immediately above the focus is called the earthquake's **epicenter**. The July 1990 earthquake in the Philippines was just 40 km below Earth's surface and the epicenter was at 15°42' N and 121°07' E near the town of Rizal, Nueva Ecija.

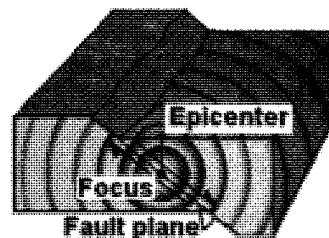


Figure 6.17 Focus and epicenter of an earthquake

The Philippines, a seismically active region, experiences about five earthquakes a day. Many of these are so weak that they pass unnoticed.

Some, however, are so strong that they cause much destruction and loss of life. In 1968, 200 people died when the Ruby Tower in Manila collapsed in a 7.3 magnitude earthquake with epicenter in Casiguran, Aurora. More than 6 000 people died when a tsunami caused by a 7.9 magnitude earthquake in the Moro Gulf hit in 1976. Then we had the July 16, 1990 earthquake with a magnitude of 7.8. The devastation is so far unequaled in deaths, property damage, and psychological shock. Damage to buildings, infrastructures, and properties amounted to at least 10 billion pesos, a part of which was caused by ground rupturing in Nueva Ecija. Nineteen buildings in Baguio were totally destroyed, while 12 were partially destroyed. There were extensive landslides at Kennon, Marcos, and Naguillian highways and widespread liquefaction (process by which sediments and soil collapse, behaving like a thick liquid when shaken by earthquake waves) in Dagupan City and parts of La Union. About 2 000 persons died.

In order to communicate information about the severity of an observable earthquake effect, its intensity and magnitude are measured. The **magnitude** of an earthquake is a measure of the energy released at the focus, the source of the earthquake. This amount can be estimated from seismograph readings and is usually expressed by the Richter Scale. Each whole value on the Richter Scale represents an increase in ground motion by a factor of 10. An earthquake of magnitude 6 has about 30 times more energy than one of magnitude 5. The stronger the earthquake, the greater is the magnitude. A quake of magnitude 2 is the smallest quake normally felt by people. Earthquakes with a Richter value of 6 or more are commonly considered strong; great earthquakes have magnitude of 8 or more on the Richter Scale. The strongest earthquake recorded so far occurred in Chile in 1960 with magnitude of 9.5.

**Intensity** measures the strength of shaking produced by the earthquake as observed by people at a certain location. Intensity does not require any instrumental measurements; it relies on reports of its effects on people, human structures, and the natural environment.

Earthquakes of large magnitude do not necessarily cause the most intense surface effects. The effect in a given region depends on the local geologic conditions (area over an unstable ground is likely to experience greater damage than one on a firm ground), focal depth, the distance from the epicenter, and the design of buildings and other structures. The extent of damage also depends on the density of population and construction in the area hit by the quake.

There is only one magnitude of a particular earthquake but the intensity could have a range of values. Typically, intensity decreases as the distance from the epicenter increases. For example, the 1968 Casiguran earthquake which had a magnitude of 7.3 had intensities in different areas as follows:

Intensity	Places
VIII	Casiguran, Quezon
VII	Manila and Palanan
VI	Baler, Quezon City, Aparri, Baguio, Dagupan, Cabanatuan
V	Tarlac, Ambulong, Infanta, Jomalig
IV	Legaspi, Lucena, Calapan, Aurora, Laoag, Catarman, Virac
III	Romblon, Vigan

What do the above intensity levels mean? Table 6.3 shows PHIVOLCS Earthquake Intensity Scale.

**Table 6.3 PHIVOLCS Earthquake Intensity Scale\***

Intensity Scale	Description
I	<b>Scarcely Perceptible</b> - Perceptible to people under favorable circumstances. Delicately balanced objects are disturbed slightly. Still water in containers oscillates slowly.
II	<b>Slightly Felt</b> - Felt by few individuals at rest indoors. Hanging objects swing slightly. Still water in containers oscillates noticeably.
III	<b>Weak</b> - Felt by many people indoors especially in upper floors of buildings. Vibration like the passing of a light truck is felt. Dizziness and nausea are experienced by some people. Hanging objects swing moderately. Still water in containers oscillates moderately.
IV	<b>Moderately Strong</b> - Felt generally by people indoors and by some people outdoors. Light sleepers are awakened. Vibration like the passing of a heavy truck is felt. Hanging objects swing considerably. Dinner, plates, glasses, windows, and doors rattle. Floors and walls of wood-framed buildings creak. Standing motor cars may rock slightly. Liquids in containers are slightly disturbed. Water in containers oscillates strongly. Rumbling sound may sometimes be heard.
V	<b>Strong</b> - Generally felt by most people indoors and outdoors. Many sleeping people are awakened. Some are frightened, some run outdoors. Strong shaking and rocking felt throughout the building. Hanging objects swing violently. Dining utensils clatter and clink; some are broken. Small, light, and unstable objects may fall or overturn. Liquids spill from filled open containers. Standing vehicles rock noticeably. Shaking of leaves and twigs of trees are noticeable.
VI	<b>Very Strong</b> - Many people are frightened; many run outdoors. Some people lose their balance. Motorists feel like driving in flat tires. Heavy objects or furniture move or may be shifted. Small church bells may ring. Wall plaster may crack. Very old or poorly-built houses and human-made structures are slightly damaged though well-built structures are not affected. Limited rock falls and rolling boulders occur in hilly to mountainous areas and escarpments. Trees are noticeably shaken.
VII	<b>Destructive</b> - Most people are frightened and run outdoors. People find it difficult to stand in upper floors. Heavy objects and furniture overturn or topple. Big church bells may ring. Old or poorly-built structures suffer considerable damage. Some well-built structures

	are slightly damaged. Some cracks may appear on dikes, fish-ponds, road surface, or concrete hollow block walls. Limited liquefaction, lateral spreading, and landslides are observed. Trees are shaken strongly.
<b>VIII</b>	<b>Very Destructive</b> - People panicky. People find it difficult to stand even outdoors. Many well-built buildings are considerably damaged. Concrete dikes and foundation of bridges are destroyed by ground settling or toppling. Railway tracks are bent or broken. Tombstones may be displaced, twisted, or overturned. Utility posts, towers, and monuments may tilt or topple. Water and sewer pipes may be bent, twisted, or broken. Liquefaction and lateral spreading cause human-made structures to sink, tilt, or topple. Numerous landslides and rockfalls occur in mountainous and hilly areas. Boulders are thrown out from their positions particularly near the epicenter. Fissures and faults rupture may be observed. Trees are violently shaken. Water splashes or slops over dikes or banks of rivers.
<b>IX</b>	<b>Devastating</b> - People are forcibly thrown to ground. Many cry and shake with fear. Most buildings are totally damaged. Bridges and elevated concrete structures are toppled or destroyed. Numerous utility posts, towers, and monument are tilted, toppled, or broken. Water sewer pipes are bent, twisted, or broken. Landslides and liquefaction with lateral spreadings and sandboils are widespread. The ground is distorted into undulations. Trees are shaken very violently with some toppled or broken. Boulders are commonly thrown out. River water splashes violently or slops over dikes and banks.
<b>X</b>	<b>Completely Devastating</b> - Practically all human-made structures are destroyed. Massive landslides and liquefaction, large scale subsidence and uplifting of land forms, and many ground fissures are observed. Changes in river courses and destructive seiches in large lakes occur. Many trees are toppled, broken, and uprooted.

\*Source: <http://www.phivolcs.dost.gov.ph/Earthquake/Scale/peis.html>

- Q6.7 The epicenter of an earthquake with a magnitude of 7.5 is in Pangasinan. Where will the intensity be highest? (a) Baguio, (b) Bicol, (c) Western Visayas, (d) Metro Manila? Why do you think so?
- Q6.8 (a) What is the relationship between intensity and magnitude of an earthquake? (b) Is it always correct to say that when the magnitude of an earthquake is high, its intensity is always high in all places? Why or why not?
- Q6.9 Hazards associated with strong earthquakes are as follows: (a) building collapse, (b) liquefaction, (c) mass wasting, (d) tsunami, (e) stream flow diversion, (f) fire, (g) dam collapse, and (h) psychological effects on people. Research on the cause and effects of each hazard.
- Q6.10 Knowing the hazards caused by earthquakes, list down how you can reduce the effects.

What should you do to prevent getting hurt during an earthquake while at home or in buildings? Answer the following questions:

- Q6.11 Which is the best place to stand in a room when an earthquake occurs? Explain your choice. Why did you not choose the others? (a) near a cabinet, (b) near the door, (c) near the window.
- Q6.12 Why is it safe to cover your head with your book during an earthquake especially when inside the room and you cannot go out of the building?
- Q6.13 Which is the best place to stay outside of a building when an earthquake occurs? Explain your choice. Why did you not choose the others? (a) open space, (b) near a tree, (c) beside a building, (d) near a shed.

## Lesson 6.4 Rocks

### The Solid Materials of Earth

What are the solid materials that make up Earth? Much of the land surface is covered by a very thin layer of soil and sand. Below the soil is rock. How much of Earth is solid rock? The crust is made up of rocks. It is less than 1% of Earth's thickness from surface to center—thickest at the mountainous parts of the continents and thinnest at the ocean floor.

Look at the rocks around you. Do you see many kinds of rocks? How is one rock different from another rock? Find out in the following activity.

#### Activity 6.6 Properties of Rocks

##### Materials

5 different rock samples	glass jar	hand lens
pan balance with set of standard masses	marking pencil	paste
graduated cylinder	strip of paper	water

##### Procedure

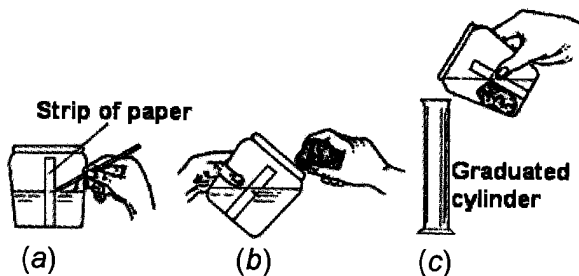
1. Collect five different kinds of rock samples. Label your rock samples from 1 to 5. Examine one rock sample. Rub your fingers over the rock.
  - a. Describe the texture of the rock.
2. Hold the rock in bright light and observe it well.

- b. What color(s) do you see in the rock?
3. Look at the rock through a hand lens.
- c. Are the particles in the rock different or the same?
- d. Describe the particle(s) in the rock in terms of size, shape, color, or any distinct characteristics.
- e. Are there some shiny particles in the rock? Are these shiny particles smaller or bigger than the other particles in the rock? Are there more of these components than other particles in the rock?
4. Examine the other rock samples. For each one, answer questions a to e. Copy the data table below and record your observations.

Rock Sample	Description	Mass (g)	Volume (cm <sup>3</sup> )	Density (g/cm <sup>3</sup> )
1				
2				
3				
4				
5				

5. Measure the mass of each rock in grams.

6. Paste a strip of paper vertically on the glass jar half-filled with water. Draw a line on the paper strip to mark the water level (Figure a). Tip the jar slightly to one side and slide in one rock carefully (Figure b) so as not to break the glass jar.



- f. What happens to the water level when the rock is placed in the jar?
- g. What causes the water level to change?
7. Pour off the water above the mark into a graduated cylinder and measure its volume (Figure c). This is the amount of water displaced by the rock. The volume of the displaced water is equal to the volume of the rock.
8. Repeat the procedure with the remaining rocks. Record your data.
- h. Which rock sank in water? Which rock floated in water?

9. Compute and record the density of each rock. The density of a substance is obtained by dividing the mass of a sample by its volume.
- i. What is the range of the densities of the rocks you collected?
  - j. Which is denser—rock or water? How can you tell?
  - k. Is air more or less dense than a rock? Than water? How can you tell?

Rocks differ in color. Some are dark; others are light-colored. They can be reddish, gray, brown, yellow, or even black. Rocks also differ in texture. Some rocks are made of tiny grains, which make them feel rough. Others are glassy in appearance and are smooth. Most rocks have shiny particles called crystals. Some rocks have large crystals; other rocks have fine crystals, or none at all. Rocks, in general, are hard. Hardness means “not easy to break, to cut up into pieces, or to squeeze into another form.” It is this hardness of rocks that keeps the shape of the earth despite the forces acting on it. It is also the hardness of rocks that enables living things to remain on Earth’s surface.

Practically all rocks are denser than air and water. Some rocks are denser than other rocks. Oceanic rocks are denser than those from the land. This finding led scientists to believe that two major kinds of rocks form Earth’s crust—a denser rock material forming the bottom layer and a lighter rock material on top forming the continents. The denser material is the same as the ocean bottom. In general, the deeper the rock the more dense it is.

## The Formation of Rocks

There are three kinds of rocks. They differ in origin. These are the igneous, the sedimentary, and the metamorphic rocks. **Igneous rocks** are those formed by the cooling and hardening of molten materials found deep in the crust or closer to the surface in or near a volcano. **Sedimentary rocks** are consolidated sediments that originally came from other rocks and were deposited by water or air. **Metamorphic rocks** are those formed by great heat and pressure from igneous and sedimentary rocks. The most abundant rocks are those of igneous origin. About 65% of Earth’s crust is made up of igneous rocks; 27% is metamorphic; and about 8% is sedimentary.

The most common exposed rock in the Philippines is igneous. This is because the Philippines has large volcanic areas which are composed of volcanic igneous rocks. Portions of the Cordillera Central, Sierra Madre, Zambales, and Mindoro mountains have igneous rocks which were

formed deep in the crust but which have been pushed up and uncovered through some geological processes. Coastal areas in the Philippines, Cagayan Valley, and Central Plains of Luzon are composed mainly of sedimentary rocks. Sedimentary rocks are sometimes found on top of mountains and hills. Examples are the hills of Montalban and Antipolo in Rizal.

## Igneous Rocks

Igneous rocks are formed from magma that cools and hardens. In general, igneous rocks are hard and tough. Igneous rocks are often divided into two groups according to the place where the magma cools and hardens. When magma reaches the surface, it is called lava. When lava cools, it hardens into **extrusive** igneous rock. Extrusive rocks are generally dark colored and heavy because they are rich in magnesium and iron. Since lava is exposed to air, it cools and solidifies quickly. Rapid cooling does not allow big crystals to form. At times, cooling may be so fast that no crystals are formed.

Magma that finds its way to the crust but does not reach the surface is called **intrusive** igneous rock. Intrusive igneous rocks cool slowly, taking thousands or even millions of years to harden. They are generally light-colored, rich in silica (like quartz and feldspar), and have large crystals.

Igneous rocks that have big crystals are described as coarse-grained. Igneous rocks that have small crystals are described as fine-grained. In Activity 6.7 you will see how small and big crystals are formed.

### Activity 6.7 Crystal Formation

#### Materials

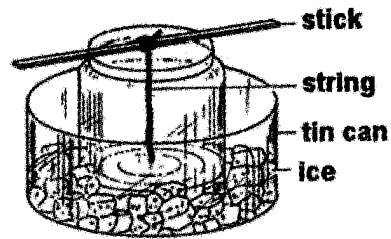
large test tube	powdered alum ( <i>tawas</i> )	hot water
stirring stick	test tube holder	alcohol burner
string	2 sticks or pencils	2 small glass jars
hand lens	can with crushed ice	

#### Procedure

1. Fill one-fourth of the test tube with powdered alum. Then pour a little hot water into the test tube. Stir the mixture. Continue adding hot water and stirring until the alum dissolves.
2. Hold the test tube over a flame until the mixture boils gently. Put more alum until the crystals cannot dissolve anymore. You now have a supersaturated solution.



3. Tie a piece of string to a stick. Pour half of the solution into a glass jar. Let the string hang in the jar. Stir the solution to cool it fast. Place the glass jar in a can filled with crushed ice.



- a. What do you see on the string?  
b. What is the string for?
4. Tie a string to another stick. Pour the remaining solution into another glass jar. Let the string hang in the jar. Let it stand overnight. The following day, examine the result with a hand lens.
- c. What do you see on the string?
5. Compare the sizes of crystals in the quickly cooled solution (placed in ice) with crystals in the slowly cooled solution.
- d. In which case are the crystals bigger?  
e. Under what conditions do big crystals form? small crystals?  
f. Where would igneous rocks cool and harden fast—deep in the crust or on the surface of Earth?

This activity partly explains how igneous rocks form both big and small crystals. Crystals take a long time to grow. A much longer time is needed for rocks under pressure inside the earth's crust to form big crystals. Molten material that cools and solidifies slowly (over thousands of years) allows enough time for large crystals to form. The longer it takes magma to cool, the bigger are the crystals formed. Molten material that cools and solidifies rapidly forms fine crystals or none at all. Igneous rocks with no crystals are described as glassy.

Q6.14 Examine the size of the crystals in igneous rock samples. How will you compare the rate of cooling of each?

In Activity 6.8 you will study several samples of igneous rocks and infer how they are formed.

### Activity 6.8 Igneous Rocks

#### Materials

labeled samples of igneous rocks such as: basalt, andesite, granite, diorite, gabbro

### Procedure

1. Examine each labeled sample of igneous rocks with a hand lens. Observe, in particular, the presence of crystals.
  - a. Are there crystals in the rock? If there are, are they large or small?
2. Copy the data table. Answer questions b to f and write your answers in the columns for each rock.

Igneous Rocks	Grain Size (fine/coarse/glassy)	Color (dark/light)	Other Characteristics	Intrusive/Extrusive	How Formed
Granite					
Gabbro					
Diorite					
Andesite					
Basalt					

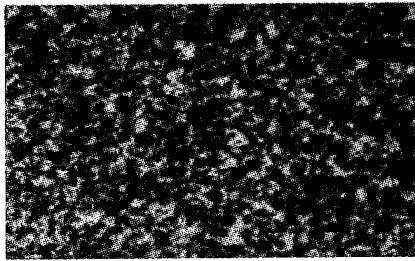
- b. Is the rock fine-grained, coarse-grained, or glassy?
- c. Is it light or dark in color?
- d. What other characteristics do you see in the rock?
- e. Is the igneous rock intrusive or extrusive?
- f. Based on the characteristics you have listed, how was the rock formed?

Figure 6.18 shows common igneous rocks in the Philippines. They are described as follows:

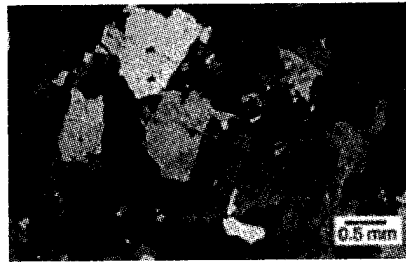
Diorite and andesite are the common igneous rocks found in the Philippines. **Diorite** is coarse-grained and generally light-colored. It is an intrusive rock that cools very slowly, deep in Earth's crust. **Andesite** is a fine-grained, light-colored extrusive rock. It is formed in lava flows.

**Granite**, a light-colored (usually gray or pink) and coarse-grained rock is made up of several kinds of crystals. The flat shining black crystals are called **biotite** and the clear colorless pieces (looks like broken glass), are called **quartz**. There are also bits of milky white or colored crystals known as **feldspar**. Granite is the most common igneous rock which forms mountains and a large part of continents.

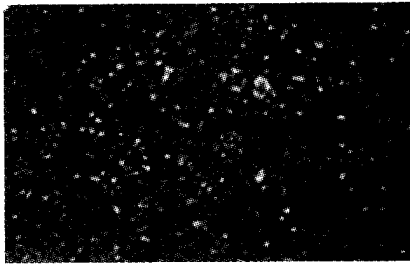
**Gabbro** is a coarse-grained rock, often called "black granite." Its dark color is due to its higher content of iron and magnesium and lower content of quartz as compared to granite. Gabbro and granite are intrusive rocks formed by slow cooling, thousands of meters under the earth's surface. The slow cooling allows enough time for molecules to form large crystals. **Obsidian** is a dark, glassy rock. It has no crystals. In



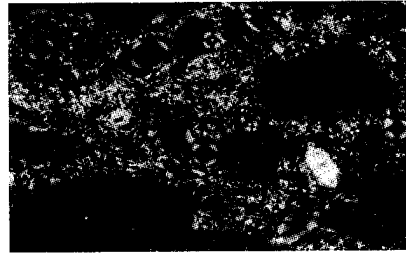
(a) Diorite



(b) Granite



(d) Basalt



(e) Scoria

*Figure 6.18 Igneous rocks*

early times, this rock was shaped into pointed and sharp-edged objects for weapons and work tools. Obsidian is from lava. Lava clots thrown into the air cool and harden as they fall forming volcanic bombs.

**Basalt**, a dark, hard, fine-grained rock is formed from lava or magma near Earth's surface. Basalt makes up the ocean floor. Molten rock materials usually contain gases which are given off during cooling and hardening. While the lava cools gases escape as the rocks are hardening, leaving small holes on the surface.

Scoria and pumice are formed in this manner. **Pumice** is light-colored and so low in density that it floats in water. **Scoria** has larger holes but is much heavier and darker than pumice.

### **Sedimentary Rocks**

Rocks that are exposed to air, water, sunlight, and some acids in the environment, wear away. Winds and plants help break rocks. Rainwater fills the cracks in rock and eventually breaks them. (The breaking of rocks into smaller pieces, either or not maintaining its original composition is called **weathering**). Water and wind through the aid of gravity erode the loose rock particles. They transport the rock particles and break them further. Glaciers that move down the mountains rub and crush the rocks along their way. As a result, rocks break into boulders, cobbles, pebbles, sand, silt, and clay. Sooner or later wind, water, or glacier deposits the fine rock particles or sediments in other places. Sediments are deposited in layers one on top of another until they become tens or hundreds of metres thick.

As new layers are deposited on top, the lower layers of sediments start to harden. They are cemented together by chemicals in the water such as calcium carbonate, silica, and iron oxides, and by the great pressure of the upper layers. Eventually, sedimentary rocks are formed. In the following activity you will study different kinds of sedimentary rocks and how they are formed.

### Activity 6.9 Sedimentary Rocks

#### Materials

labeled samples of sedimentary rocks such as: limestone, shale, sandstone, and conglomerate	pebbles or fine gravel
fine sand, about 100 mL	soil, about 100 mL
water, about 100 mL	2 tall glass jars
	hand lens
	stirring stick

#### Procedure

1. Examine each sample of sedimentary rock with a hand lens. Feel the samples and compare them.
  - a. Which samples are smooth? Which ones are rough?
  - b. In what way are they different when seen through a hand lens?
2. Pour water into a tall jar until it is two-thirds full. In another jar, mix about 100 mL each of soil, fine sand, and pebbles. Add about 100 mL of water and stir the mixture. Pour the mixture into the first jar with water. Observe how the different particles settle.
  - c. Which particles settle first? Why?
  - d. Which particles settle last? Why?
  - e. How are the particles arranged in the jar?
3. Draw the arrangement of particles.
  - f. If particles of different sizes were deposited at the same time, would they form different layers?

Many sedimentary rocks show a layered arrangement of particles. Smaller particles settle more slowly than the larger particles as you have seen in Activity 6.9. Figure 6.19 shows bigger particles deposited at the bottom.

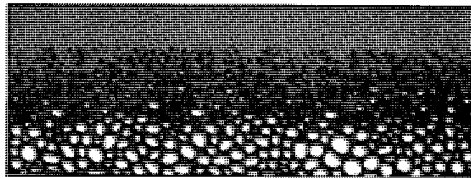


Figure 6.19 Layering in sediments

Deposition of particles in one place is also affected by the strength of the water current that carries them. Strong water current can carry small particles of gravel, sand, and clay to longer distances depositing the bigger rock fragments nearer and depositing the smaller ones farther. As the water current weakens gravel and pebbles would be carried in shorter distances. Figure 6.19 shows decreasing water current in that place. The bigger particles could have been deposited during rainy months while the upper layer during summer. The cycle continues for the next season and another layer like the one shown in the figure will form over the old layer.

As layer after layer of eroded earth materials is deposited on top (Figure 6.20), the layers are pressed down more and more through time, until the bottom layers slowly turn into rock. This process is called **lithification**. If the place is undisturbed, the layers found below are older than those on top.

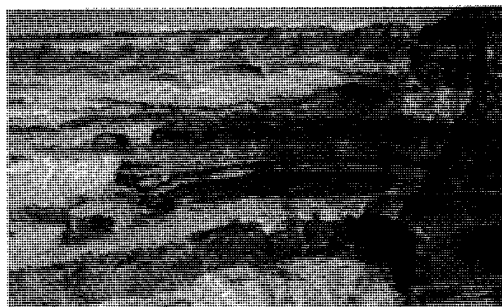


Figure 6.20 Grand Canyon, U.S.A.

Some sedimentary rocks contain the remains or traces of living things such as shells, fishes, or even plants and mammals. These remains or traces are called fossils (Figure 6.21). Fossils are important in the study of Earth's past. They can also tell something about the age of rocks, and therefore, about the age of the earth.

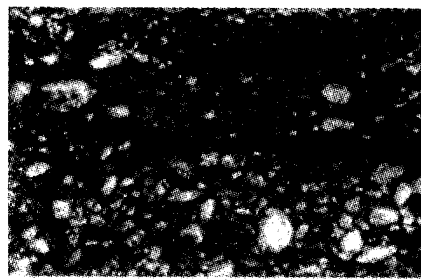


Figure 6.21 Fossils embedded in sedimentary rock

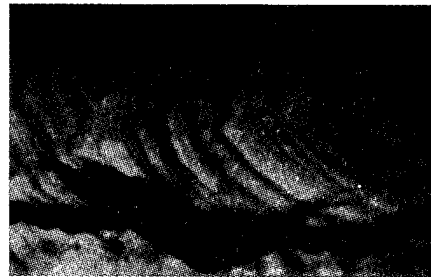
Figure 6.22 shows the most common types of sedimentary rocks which are described as follows:

**Conglomerate** is a rock consisting of pebbles or pieces of gravel cemented together. The rounded shapes of pebbles indicate that they came from afar before they were deposited and formed into rocks. They must have rubbed against each other and the river bottom as the currents of water carried them. Conglomerate is usually formed in riverbeds, at the foot of mountains, and along beaches.

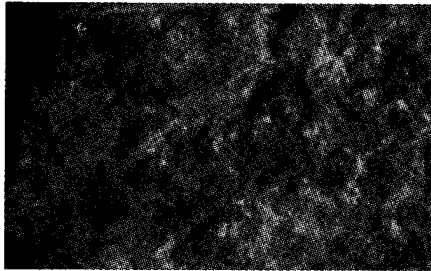
When layers of sand grains deposited by water or wind become more tightly packed and cemented together, they form **sandstone**. Sandstone may form where water current is slow as in a valley, lake, or sea. Sandstone is rough. It is often used to sharpen knives and other tools.



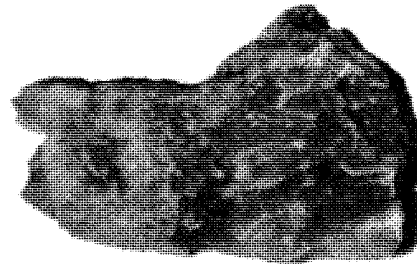
(a) Conglomerate



(b) Sandstone



(c) Shale



(e) Gypsum

Figure 6.22 The most common types of sedimentary rocks

The wide variety of colors observed in sandstone is due to the composition of sand or to the kind of cement that binds its particles. White or light-colored sandstone is bound together by cement of silica or calcium carbonate. Red, brown, and yellow sandstone are bound by iron oxide.

**Shale** is hardened clay. It is the most common sedimentary rock, making up 50% of the exposed rocks on earth. Layers of clay particles mixed with fine sand, organic matter, iron oxide, and other impurities form shale. Because of its fine particles, shale is smooth and has tiny openings. It is soft rock that splits easily into its layers.

**Limestone** is composed mostly of calcium carbonate. Limestone may form from the action of plants and animals living at the bottom of lakes and oceans. These plants and animals store calcium carbonate in their shells and skeletons. When these organisms die, their shells and skeletons settle on the bottom of the ocean, become compacted and cemented together, and form limestone. This is **coquina**. Limestone is also formed directly by living organisms as in a coral reef.

Continuous evaporation of water from lakes and shallow seas leaves calcium carbonate in excess of what can be held in solution. The excess calcium carbonate settles down from the solution to the bottom of the lake or sea. Large amounts of deposited calcium carbonate become compacted and harden to form limestone rock. The same process happens when hydrated calcium sulfate in seawater settles, forming **gypsum**.

## Metamorphic Rocks

Under great pressure and temperature, igneous and sedimentary rocks change in texture, color, and crystal structure. The changed rocks are called **metamorphic rocks**. Metamorphic rocks are commonly harder and denser than the igneous or sedimentary rocks from which they came. In Activity 6.10 you will compare metamorphic rocks with the original rocks from which they came.

### Activity 6.10 Metamorphic Rocks

#### Materials

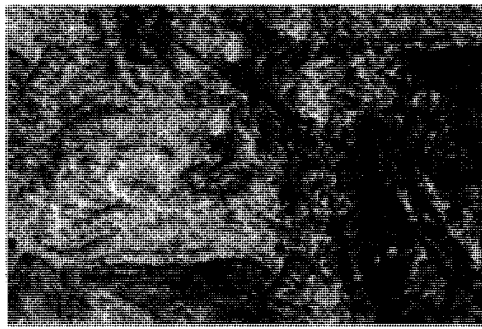
- labeled samples of metamorphic rocks: marble, slate, quartzite, and gneiss
- labeled samples of sedimentary rocks: sandstone, shale, and limestone
- labeled sample of igneous rock such as granite
- hand lens

#### Procedure

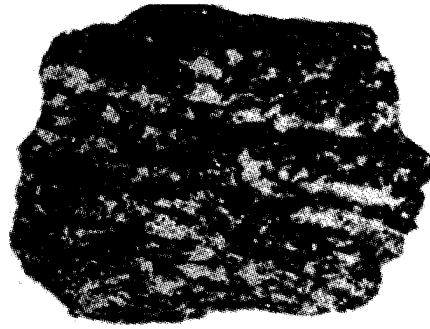
1. Arrange the igneous and sedimentary rocks on the table. Put the marble beside the limestone, gneiss beside granite, slate beside shale, and quartzite beside sandstone. Each metamorphic rock is paired with the rock it came from.
2. Examine the pairs of rocks.
  - a. Are metamorphic rocks similar to the rock from which they came?
  - b. If not, in what way do the two differ?

Figure 6.23 shows some examples of metamorphic rocks which are described as follows: **Marble** is the most widely known metamorphic rock. It is formed from limestone. It is denser and harder than limestone. Pure marble is white. The attractive colors of marble are caused by impurities in the rock such as carbon and iron oxide. Because of its hardness and attractive colors, marble is used as a building material. It is also used in making furniture and other ornaments.

**Gneiss** (pronounced nice) is formed from conglomerate or granite. Light and dark bands of minerals, a condition known as foliation, are its most striking features. **Quartzite** is formed from sandstone. It is heavy, hard, nonporous, and has a grainy texture. It has the same color as the sandstone it came from. In the Philippines what is known as "piedra china," a highly prized building stone, is actually quartzite.



(a) Marble



(b) Gneiss

Figure 6.23 Examples of metamorphic rocks

In general, rocks can be identified by their common characteristics. Sedimentary rocks are almost always found in layers. The layering, however, may not be seen in a small sample. Sedimentary rocks usually appear dull, except in some limestone, and may contain fossils. Igneous rocks are usually dense and made of interlocking crystals. Like igneous rocks, metamorphic rocks are also dense. However, the mineral grains of metamorphic rocks may be arranged in parallel layers which can be seen from the edge as bands.

Rocks do not always remain the same. Igneous, metamorphic, and even sedimentary rocks may be weathered, eroded, and deposited. The deposited materials become compacted and cemented together to form sedimentary rocks. Sedimentary and igneous rocks under high pressure and temperature may change their crystal structure, texture, and color to form metamorphic rocks. Rocks at the bottom of the crust may melt to form magma again. This continuing change from one kind of rock into another is called the **rock cycle** (Figure 6.24). You will encounter some of the terms later in this unit.

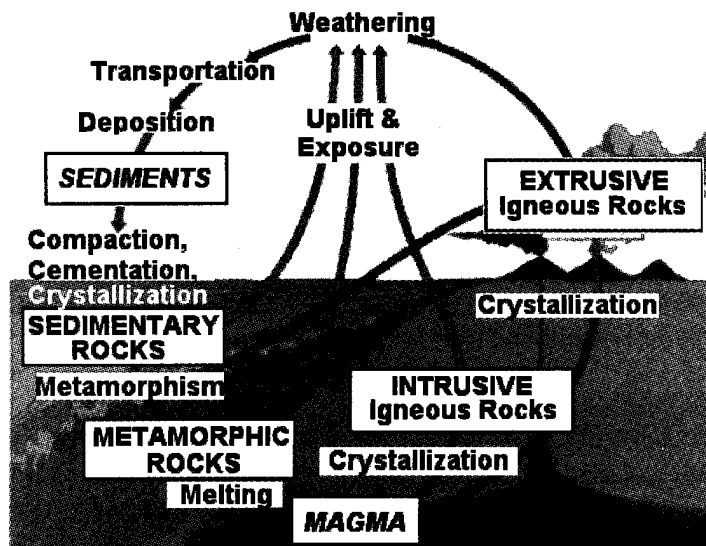


Figure 6.24 The rock cycle



Q6.15 Study Figure 6.24 and answer the following questions: (a) What processes change sedimentary rocks into metamorphic rocks? (b) What processes change metamorphic rocks into sedimentary rocks? (c) What processes change igneous rocks into sedimentary rocks?

## Lesson 6.5 Minerals in Rocks

In some rock samples you examined, you saw crystals. In one rock it is possible to find different kinds of crystals. Each crystal is a mineral and a rock may be made up of one or more different kinds of minerals.

A **mineral** is a naturally formed solid element or compound in which atoms and molecules are bound together in a definite orderly arrangement to form crystals. Most of these crystals are too small to be seen even under a microscope. But some crystals are big enough to be identified. A few crystals may grow big enough to be separated from the rock and polished for jewelry. The most beautiful crystals are called **gems**. The most prized gems are diamond, amethyst, and opal. Metallic crystals, like iron pyrite, are also used for jewelry. Pyrite (iron sulfide) is often referred to as “fool’s gold” because it looks like gold.

### Identifying Minerals

Minerals are most easily identified by their physical properties. No expensive or complicated instruments are needed in identifying minerals using their physical properties. In Activity 6.11 you will learn about a few physical properties which you can use in identifying minerals in rock samples.

#### Activity 6.11 Some Properties of Minerals

##### Materials

black paper or any colored paper	¼ teaspoon iron filings
¼ teaspoon copper filings	¼ teaspoon fine sand
¼ teaspoon powdered chalk	hand lens
a pinch of salt crystals	5 different rock samples

##### Procedure

1. Mix together on paper the iron filings, copper filings, powdered chalk, and sand. Examine the mixture through a hand lens.
  - a. Can you differentiate the materials you mixed together?

2. Look at the mixture again.
  - b. Are some of the materials brighter than others?
  - c. Which ones are shiny?
  - d. Which ones are dull?
3. Place a pinch of salt on the paper. Examine the salt particles with the hand lens.
  - e. What is the shape of the salt particles?
  - f. How can you differentiate one material from another?
4. Examine several rock samples with the hand lens.
  - g. How can you differentiate one rock from another?

You can easily pick up bits of copper, iron, chalk, and sand from the mixture. You can distinguish the different materials from each other. You can do all these because these materials have different colors. Rocks vary in color because of the different minerals they contain.

**Color** is one way of telling one mineral from another. It is their usually most noticeable and interesting property. But it is not the most reliable. One mineral may come in different colors, and several minerals may have almost the same color. For example, gold is yellow, copper is reddish, and iron is gray. But silver, tin, and magnesium have almost the same gray-white color.

Every material has its own way of reflecting light. Some minerals like copper and iron are shiny. They reflect more light than chalk. Others, like chalk, are very dull and do not shine. **Luster** is the appearance of a surface that reflects light. Gold, copper, iron, and tin are minerals with a metallic luster. Pearl and opal have a pearly luster, which is nonmetallic.

Each grain of salt you looked at was like a tiny block or cube. Each block is a crystal. One of the most interesting properties of minerals by which they are identified is the natural shape of their crystals. Minerals of the same kind have the same crystal shape. Galena crystals are cubic and quartz crystals have six equal sides.

Rubbing a rock or mineral sample on a piece of unglazed tile leaves a mark called streak. **Streak** refers to the color of the powder a rock or mineral leaves behind when rubbed on a rough surface. The color of the streak, however, is not always the same as the color of the mineral. For example, the mineral pyrite, which has the same color as gold, leaves a greenish-black streak, while gold always leaves a gold streak.

You can scratch some rocks or minerals with your thumbnail, others with a piece of glass or steel knife. Some minerals are harder than others. Diamond is known to be the hardest mineral. **Hardness** is the resistance of a mineral to scratching. Harder substances can scratch softer ones, but not vice versa. Polished mineral gemstones should never undergo a hardness test because scratch marks can bring down their value.

A hardness scale proposed by Friedrich Mohs about a hundred years ago is used in the study of minerals today. In the Mohs scale, ten minerals are listed in the order of their increasing hardness. Any mineral in the list can be scratched by the minerals after it. For example, quartz, ranked 7, is harder than any of the six minerals before it. Topaz, ranked 8, is harder than any of the seven minerals before it. Table 6.4 describes simple tests for each rank if a set of the standard minerals is not available.

To test the hardness of a mineral, look for the mineral in the hardness scale that might scratch it. Two minerals of the same hardness can scratch one another. To make sure a mark on a mineral is actually made, rub off what appears as a mark with your moistened finger and feel it. You might find it necessary to use a hand lens.

Bubbles may form when acid is used on some minerals. The bubbles are carbon dioxide gas given off when the acid reacts with the minerals. What kind of mineral produces bubbles when reacting with an acid like hydrochloric acid?

Cleavage and fracture describe the way a mineral breaks. Any irregular break is termed **fracture** (Figure 6.25). **Cleavage** is the tendency of certain minerals to break along one or more planes when put under pressure. Ordinary or table salt shows cleavage.

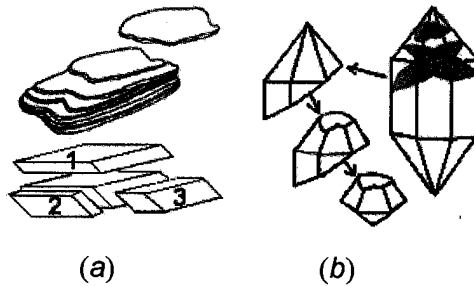


Figure 6.25 Cleavage and fracture of minerals

Table 6.4 Mohs Scale of Hardness and Equivalent Easy Test

Hardness Rank	Mineral	Easy Test
1	talc	Touching the mineral leaves soft greasy flakes on fingers; easily scratched by the fingernail
2	gypsum	Fingernail barely makes scratch marks on mineral
3	calcite	Mineral is easily cut by steel knife or scratched by a copper coin
4	fluorite	Steel knife edge easily makes scratch marks on mineral but does not cut it; not hard enough to scratch glass

5	apatite	Edge of steel knife pressed or rubbed hard on mineral makes scratch marks; barely scratches ordinary glass
6	orthoclase	Not scratched by a steel knife. Steel file easily makes scratch marks; easily scratches window glass and glass bottles
7	quartz	Mineral rubbed hard on glass and steel makes scratch marks on them
8	topaz	For minerals 8 to 10, no easy test except rubbing against the next harder mineral; thus, corundum leaves scratch marks on topaz and diamond on corundum
9	corundum	
10	diamond	

Not one property, be it color, streak, crystal shape, hardness, or specific gravity is enough to identify a mineral. But together, they can be useful in identification. Do Activity 6.12 to identify some minerals.

### Activity 6.12 Identifying Minerals

#### Materials

unglazed tile	10% hydrochloric acid
identified mineral specimens	piece of glass
steel knife	medicine dropper
small hammer	Newspaper
hand lens	

#### Procedure

1. Sketch the specimen.
2. Describe the color of the specimen. Record your observations in a data table similar to the one shown below.

Sample Number	Color	Streak	Cleavage	Luster	Hardness	Other Properties

3. Rub the specimen on an unglazed tile. Note the mineral's color on the tile or its streak.
4. Do you see planes in the mineral crystals? Check the box if cleavage is present; if not, put an "X."

5. Describe the luster of the mineral—metallic (M) or nonmetallic (NM). You can further classify nonmetallic luster into:
  - resinous – like plastic
  - pearly – like that of pearl
  - vitreous – like the luster of glass
  - earthy – like the luster of soil
  - adamantine – like the luster of diamond
6. Scratch the mineral sample with your thumbnail.
  - a. Did your thumbnail leave a mark on the mineral?
7. If your thumbnail did not leave a mark on the mineral, scratch the mineral with a piece of glass. If no mark results, scratch the mineral with a steel knife.
  - b. What property of the mineral are you testing when you try to scratch it with different things?
  - c. How will you describe the mineral samples scratched by your thumbnail?
  - d. How will you describe the mineral samples scratched by the piece of glass?
8. Try scratching each mineral with the others.
  - e. Which of the three minerals is the softest? the hardest?
9. Line your worktable with newspaper to protect it from the acid. Place the mineral samples in a row on the newspaper.
10. Fill the medicine dropper with hydrochloric acid. Put a drop or more of the acid on each mineral sample. Use a hand lens in observing the minerals while making the test.
  - f. In which mineral samples do bubbles form?
  - g. In which mineral samples do bubbles not form?
  - h. What does bubbling tell about the mineral?
11. Examine one mineral sample with the hand lens. Try breaking it. See how it breaks. Do the same with the other samples.
  - i. Does the mineral break into small, uneven pieces or regularly-shaped pieces or thin sheets?
12. Compare your sample with a table on the physical properties of some common minerals to be provided by your teacher.

There are about 2 000 known minerals but only a little more than 100 are of economic importance. Minerals may accumulate extensively and form mineral deposits. A mineral deposit from which a metal may be extracted profitably is called a **mineral ore**. **Ores** are rocks or mineral deposits from which metals such as gold, silver, copper, platinum, or lead can be obtained commercially.

Areas where diggings are made to extract mineral ores are called **mines**. Where are our mines? What kinds of minerals do we mine? Among the important metal minerals that are mined in the Philippines are iron which is usually deposited with other minerals like nickel, bauxite, cobalt, and chromite. Bauxite is an aluminum compound. Copper, gold, silver, chromium, and mercury are the other major metals mined in the country. Gold is the only precious metal which can be found in its pure form. Silver is not mined as a separate metal but as a by-product of gold mining. Silver may also be related to another metal or mineral like galena (an ore from which the metal lead is obtained). The Philippines has some of the best quality copper deposits in the world because of its high gold content that can be recovered. Copper deposits are often associated with diorite rock formations. Cobalt is obtained as a secondary product in the processing of metals like copper, nickel, lead, zinc, and gold.

Our nonmetallic minerals include dolomite limestone, marble, feldspar, silica, and clay. Limestone is used for making cement. Feldspar is important in the manufacture of tiles and ceramic toilet ware. Silica is principally used for making glass. Clay is used for pottery and marble is for building construction.

The uses of minerals depend on their characteristics. List down materials you have at home which you think have minerals.

## **Conservation of Mineral Resources**

The demand for minerals constantly changes. What may be important today may no longer be so later. The high cost of transportation and production, limited supply, uneven distribution, and environmental effects may change the need for a mineral. Discovery of other materials which are more available and cheaper to use is also another factor.

Before the 1960's, people seldom thought of conserving resources because of their abundance. The export of minerals became a boost to export trade. But the rapid rise in population not only increased the demands for more agricultural products but also for more manufactured goods. More minerals were used in industrialization and mechanization. Now the Philippines is faced with the problem of diminished natural resources and destruction of the environment in our effort to mine our mineral resources.

The total volume of Earth's workable mineral deposits is only 1% of the crust. Mineral deposits are nonrenewable. They cannot be grown within a lifetime like trees and plants. Nature cannot replace them once they are removed from Earth's crust. Unless we learn to use these mineral resources wisely, the future generations will suffer from their loss.

No nation is entirely self-sufficient in minerals. The geographic distribution of minerals is uneven and calls for nations to work together toward conservation. Mineral conservation demands the intelligent use of mineral resources and respect for the rights of the coming generations. It means encouraging the actual saving of materials, recycling or reuse of all possible products, reducing waste by working for maximum recovery of metals from mines, controlling corrosion, and using alloys.

Mixing the expensive minerals with the less expensive ones and non-mineral substances saves on the use of expensive minerals and also adds to its desirable characteristics. For example, the durability of stainless steel is due to the combination of nickel, chromium, and molten steel. Molybdenum makes iron easier to draw into fine wires and to hammer into thin sheets. Bronze is made by combining copper and tin while brass is combined copper and zinc. Can you think of other combined metals?

Substitutes also reduce the amount of valuable metal used. Aluminum, as a good conductor of electricity, is a cheaper and more available substitute for copper in high tension wires. Nylon and other synthetic fibers, known for their durability, substitute for metal wires. Plastics are now used in place of many metal parts in machinery and tools.

Conservation through research and discovery may brighten our future by lengthening the life span of our mineral resources. Through research, it is possible to arrive at more efficient use of minerals and to develop substitutes. Through discoveries, our known mineral supplies can be increased.

Limited mineral resource should not only be the factor to consider in conserving them. Mining operations result in adverse effects not only on the environment but also on the people. They displace communities including indigenous peoples from their ancestral lands. People living near mining areas are exposed to unnecessary hazards with little personal or community benefits. Job opportunities are given to migrant workers.

Mining harms the environment and degrades the quality of life of the people in mining communities. Some environmental issues related to large scale mining operations include:

- proliferation of mine tailings and tailings ponds which affect main rivers and their tributaries;

- siltation of water systems precipitated by mill tailings ponds, mine wastes, and other natural land surfaces;
- disturbance of natural land surfaces as mining levels forests and vegetation;
- air pollution due to dust arising from emissions and movements of heavy equipment; and
- siltation of the water systems including the seas affects the coral reefs and marine life.

Some mining companies though have taken steps to reduce the above-mentioned environmental effects.

Q6.16 As ordinary citizens, we can help conserve our mineral resources. Make an inventory of materials and equipment made from minerals which are used in homes and schools. Then list down ways of conserving them.

## Lesson 6.6 Weathering, Erosion, Transportation, and Deposition

Earth's surface is constantly changing. These changes may come about suddenly, as in the eruption of a volcano or in the occurrence of earthquake. Most changes, however, happen very, very slowly. They take much more than a lifetime. We cannot see them happen but we can only guess about them or infer from them. In this lesson, you will study how land surfaces are worn away, moved, and deposited.

### Weathering

You have learned in Lesson 6.4 that the lithosphere is made up of rocks. We usually think of rocks as symbols of hardness and strength. In fact, you may often use a piece of rock for hammering because you know that rocks are hard. Some people build stone houses because they last longer than houses made of wood or bamboo. But are rocks as hard and strong as they appear to be? Activity 6.13 will show you if rocks are as hard as they look.

#### Activity 6.13 Weathering

##### Materials

3 or 4 different rocks	marking pencil
hand lens	4 plastic or brown paper bags
hammer	



### **Procedure**

1. Wash the soil from the rock samples. Dry and number them. Use the numbers in referring to the rocks. Look at one rock through a hand lens.
  - a. What is its color?
  - b. Is the rock smooth or does it have tiny, shallow holes?
  - c. What else do you notice?
2. Put the rock in a plastic bag. With a hammer break it into two or three pieces. Examine the freshly cut surface of the rock with the hand lens.
  - d. Is the color of the freshly cut surface exactly the same as the color of the old exposed surface?
  - e. Is the fresh cut surface smooth or does it have holes?
3. Scratch the freshly cut surface and the old exposed surface.
  - f. Which surface is harder? Why?
4. Examine, describe, and then break up other rocks as you did the first rock. Answer questions a to f for each rock.

The outer part of rocks looks different from their inner part. The discolored outer part is softer and breaks more easily with pressure than the inner part.

The surface of rock long exposed to wind and water is usually smooth and rounded compared to the newly broken pieces. In some cases, the exposed surface may have holes. The weakening and breakdown of rocks into small pieces is called **weathering**.

Weathering is the combined action of physical (or mechanical) and chemical processes that change the physical and chemical character of rocks and minerals at or near Earth's surface. Chemical and physical processes work together and act simultaneously to break down rocks and minerals to smaller fragments. A biological process of weathering is either a physical or a chemical weathering. Weathering is typically a long process. It affects rocks and minerals not only in their natural setting but also those used in buildings and structures made by humans.

### **Physical Weathering**

**Physical or mechanical weathering** involves the breaking down of rocks into smaller pieces, without any changes in their composition. The

processes that may cause physical or mechanical rupture are wetting and drying, pressure release, frost wedging, thermal expansion, salt growth, and abrasion.

Alternate wetting, swelling, and drying of rocks, sometimes known as **slaking**, occurs by the accumulation of successive layers of water molecules in between the mineral grains of a rock. The increasing thickness of the water pulls the rock grains apart. Also, under dry conditions, air that is drawn into rock pores and trapped as water advances into rock can exert considerable stress.

Rocks that form deep under Earth's surface are created at much higher pressures and temperatures. There are geologic processes that expose these rocks. When this happens, pressure on the rock is greatly decreased. As a result, the rock expands and develops cracks. This process is called **pressure release** or unloading (Figure 6.26).

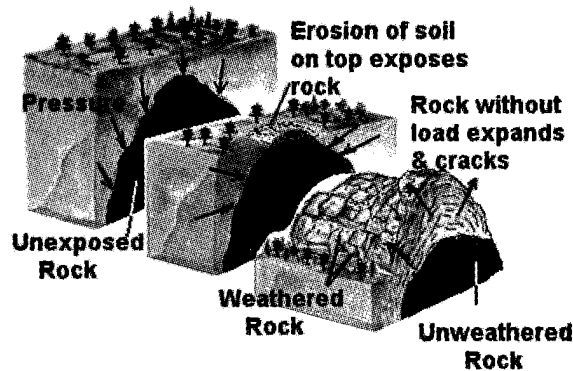


Figure 6.26 When the pressure on the rock due to soil overlying it is removed, the rock expands and cracks.

**Frost wedging** is the most effective process of physical weathering in cold countries. Water that seeps into rock cracks freezes during colder months. You must have noticed that water placed in the freezer expands when it turns to ice. Hence, the expanded frozen water in rock cracks exerts pressure on the rock segments. Alternate freezing and thawing (melting) of water in between rock fractures and pores breaks rocks (Figure 6.27).



Figure 6.27 Rock weathers due to freezing and melting of water in rock cracks.

Rocks are not good conductors of heat. Sudden exposure to high temperature, as in a forest or grass fire may cause **thermal expansion** of the outer part of the rock only. This leads to eventual breakage of the rock.

Water in fractures and pore spaces of rocks may contain salts, which are left behind when water evaporates. The salt crystals grow as water flows into and evaporates. The crystals generate stress that eventually ruptures the rock.

**Abrasion** occurs when some forces cause two rock surfaces to come together causing mechanical wearing or grinding of their surfaces. Collision between rock surfaces normally occurs through the transport of material by wind, water, or ice.

### **Home Activity**

When you get the chance to go to a river, pick up some stones upstream and near the sea. Compare their surfaces. Which is smoother? Why?

Whatever processes of physical weathering are at work, as rocks disintegrate into smaller fragments, the total surface area increases allowing more extensive chemical weathering by water and air.

### **Chemical Weathering**

**Chemical weathering** is the breaking down of rocks and minerals into small-sized particles through chemical reaction from exposure to water and atmospheric gases such as carbon dioxide, oxygen, and water vapor. Chemical reactions in rocks cause new chemical products to be formed. The chemical reactions generally begin at the rock's surface or along contacts between mineral grains. The more surface area the rock has, the more chemical reactions can take place. For these chemical reactions to happen in nature there has to be moisture and heat. The new compounds produced are generally softer and more soluble than the original rock or mineral. In addition, because the new compounds produced are smaller in sizes, the surface area exposed to weathering is greater.

The most common agents of chemical weathering are water, oxygen, and acids. Water can dissolve many materials. Salt and some minerals (halite and calcite) are soluble in water. Oxygen is an active element so that it combines with minerals that are exposed at Earth's surface. The most common oxides are those of iron and aluminum, resulting in red and yellow staining of soils, respectively. Oxidation makes rocks softer (think of an iron bar rusting). It gives altered Earth materials a characteristic yellow brown to red color. This process is greatly speeded up in the presence of water and warm temperatures.

Acid is the most effective agent of chemical weathering. Naturally occurring acids are sulfuric and hydrofluoric acids emitted during volcanic eruptions and drain from some mines. Sulfurous gas in polluted air

combines with rain to form sulfuric acid. Carbonic acid is produced in rainwater by reaction of the water with carbon dioxide (CO<sub>2</sub>) gas in the atmosphere. Although a weak acid, it is so abundant at Earth's surface that it is the single most effective agent of chemical weathering. Soil gas has more CO<sub>2</sub> content than air since this is a product of organic matter decay. And as rainwater percolates through soil, it becomes more acidic and readily attacks minerals in the unweathered rock below the soil. The combination of acid with limestone in rocks results in caves or caverns and sinkholes.

**Biological weathering** involves the disintegration of rock and mineral due to the chemical and/or physical agents of an organism. The types of organisms that can cause weathering range from bacteria to plants to animals. Animal-burrowing organisms like rodents, earthworms, and ants bring materials to the surface where it could be exposed to the agents of weathering. Growing plant roots exert pressure on rocks. When tall trees sway in a strong wind, these loosen rock material and enlarge passageways for water and air. Organisms produce carbon dioxide that forms carbonic acid with water, and organic substances that have the ability to decompose minerals and rocks. They influence the moisture regime in rocks and, therefore, enhance weathering.



*Figure 6.28 Roots of plants make cracks in rocks larger*

There are several factors that control weathering. One of them is climate. Nearly all weathering involves water, mostly direct wetting and drying, salt crystallization, and frost wedging. All chemical weathering is in a solution with water. The presence of soil on the surface of a rock enhances weathering since it promotes vegetation, creates home to organisms that form acids, and holds water. Topography controls the amount of soil on a rock. The steeper the slope, the less soil is retained, all other factors equal. On gentle slopes, the weathering products accumulate and stay in contact with rock for longer periods of time. This results in higher weathering rates. Another factor that controls weathering is the rock type and structure. Different rocks are composed of different minerals. Each mineral has a different susceptibility to weathering. Bedding planes, joints, and fractures of rocks all provide pathways for the entry of water. A rock with lots of these features will weather more rapidly than a massive rock containing no bedding planes, joints, or fractures.

Q6.17 Which of the following observations indicate that a rock has been weathered mechanically? (a) The outer and inner parts of the rock have different colors. (b) The rock is smooth with rounded edges.

(c) The outer part of the rock is soft and crumbly. (d) The rock is covered with unconsolidated materials.

## Erosion

If tectonism were not at work, the surfaces of the continents would long ago have been reduced to featureless plains due to weathering and erosion.

Materials on mountain slopes or hillsides are not in equilibrium with respect to gravity. Because of the force of gravity, the various agents of erosion (moving water, glaciers, and wind) work to make slopes gentler and therefore increasingly more stable.

**Erosion** is the removal of weathered rock and soil materials from its location by the agents of erosion. Through erosion the surface of the earth is constantly being sculptured into new forms. The shapes of continents are continuously changing, as waves and tides cut into old land while silt from rivers builds up new land. As rivulets, streams, and rivers cut their channels deeper, gullies become ravines and ravines become valleys. The Grand Canyon (Figure 6.20), more than 1500 m deep, was produced by erosion probably within the past 5 million years. The overall effect of the wearing down of mountains and plateaus is to level the land; the tendency is toward the reduction of all land surfaces to sea level.

Water plays an important role in erosion by carrying away material that has been weathered and broken down. When an area receives more water (in the form of rain, melting snow, or ice) than the ground can absorb, the excess water flows to the lowest level, carrying loose material with it. This erosion may be balanced by the formation of new soil. Often, however, in areas having little vegetation, the runoff leaves a pattern of gullies formed by rivulets. Water can even erode solid rock, especially along streambeds where the stones that are carried with the current scour and abrade into bedrock.

Without human activities, losses of soil through erosion would in most areas probably be balanced by the formation of new soil. On virgin land a mantle of vegetation protects the soil. When rain falls on a surface of grass or on the leaves of trees, some moisture evaporates before it can reach the ground. Trees and grass serve as windbreaks and a network of roots helps to hold the soil in place against the action of both rain and wind. Agriculture and lumbering, as well as housing, industrial development, and highway construction, however, partially or wholly destroy the protective canopy of vegetation and greatly speed up erosion of certain kinds of soils. Erosion is less severe with crops such as rice, which cover the ground evenly, than with crops such as corn and tobacco, grown in rows.

Overgrazing or *kaingin* system, and careless cultivation, which in time can change grassland and forest land to desert, have disastrous effects.

## Transportation

Transportation is the movement of eroded particles by agents such as rivers, waves, glaciers, or wind. During transportation, the sharp edges and corners of rock fragments are ground. This process is called **rounding**. Rounding occurs in the sand and gravel as rivers, glaciers, or waves cause particles to hit and scrape against one another or against a rock surface, such as a rocky stream bed. Boulders in a stream may show substantial rounding in about 1 km of travel. Rounding during transportation is very rapid.

**Sorting** is the process by which sediment grains are selected and separated according to grain size (or grain shape or specific gravity) by the agents of transportation, especially by running water. Sediment is considered well-sorted when the grains are nearly all the same size. A river is a good sorting agent, separating sand from gravel, and silt and clay from sand. Sorting takes place because of the greater weight of larger particles. Boulders weigh more than pebbles and are more difficult for the river to transport. Thus, a river must flow more rapidly to move boulders than to move a pebble. Similarly, pebbles are harder to move than sand and sand is harder to move than silt and clay.

## Deposition

**Deposition** is the settling or coming to rest of transported materials. Sediment is deposited when running water, glacial ice, waves, or wind loses energy and can no longer transport its load.

Q6.18 A white rock when exposed to air turns reddish brown. What do you think happened to the rock? What kind of weathering has it undergone?

## Lesson 6.7 Soil

Soil is an important natural resource. It serves as the interface between the lithosphere and the biosphere since soil provides nutrients for plants. Soil consists of weathered rock plus organic materials that come from decaying plants and animals. The same factors that control weathering control soil formation.

How important is soil to you? Healthy soil gives you clean air and water, bountiful crops and forests, productive rangeland, diverse wildlife,

and beautiful landscapes. Soil does all this by performing five essential functions:

- regulates the flow of water on land;
- sustains plant and animal life;
- filters potential pollutants. The minerals and microbes in soil are responsible for filtering, buffering, degrading, immobilizing, and detoxifying organic and inorganic materials, including industrial and municipal by-products and atmospheric deposits;
- aids in cycling nutrients. Carbon, nitrogen, phosphorus, and many other nutrients are stored, transformed, and cycled through soil; and
- supports structures on Earth.

## Soil Formation and Soil Profile

Soil is formed from weathered rocks and decayed plant and animal matter. It is the result of the action of climate and plant and animal life over a period of time. The layer of loose weathered material increases in thickness with time. As the layer of weathered rock becomes thicker, plants start to grow on it. Small organisms increase in number. Dried leaves, dead plants and animals, and animal wastes are deposited on the weathered rock materials. Bacteria and other small organisms act on the deposited materials, resulting in its decay into humus. Rainwater causes the weathered rock materials and the humus to react and develop into soil. Humus and minerals make the soil fertile.

A soil may develop characteristics different from the rock it came from. Soil layers or horizons that is distinct from one another make up a **soil profile** (Figure 6.29).

When the layers in a soil profile are well developed and can be distinguished from one another, the soil is said to be **mature**. The layers of young soils are not fully developed. They still show characteristics of the parent material they come from. Most soils in the Philippines are considered young mainly because most of the topsoil is usually eroded by heavy rains. The newly exposed layer will take time again to develop into mature soil.

The different layers of a mature soil profile are the *O*, *A*, *B*, *C*, and *R* layers. The *O* or the **surface litter layer** is dominated by organic

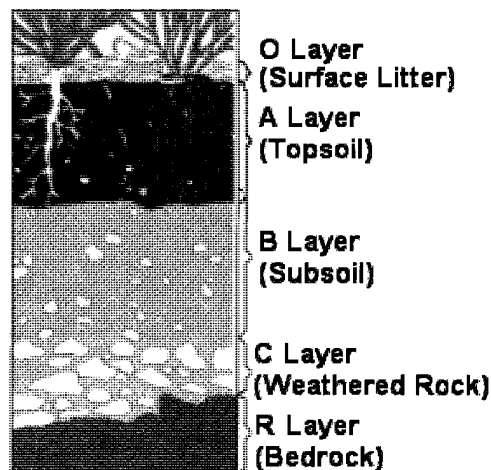


Figure 6.29 The layers of a mature soil horizon

materials, consisting of undecomposed or partially decomposed litter, such as leaves, needles, twigs, moss, and lichens, which have accumulated on the surface. The **A** or the **topsoil layer** is composed of humus (organic matter) mixed with minerals having different form and structure from the original or parent rock. It also has some living organisms. The **B layer** includes humus and clay leached from the overlying layers. Its organic materials have different structures and form from that of the bedrock. The **C layer** is composed of weathered materials some of which have different form and structure from the parent rock. Plant roots can penetrate the C layer, which provide an important growing medium. The **R layer** is hard bedrock underlying the soil. It is impractical to hand dig the layer, although it may be chipped or scraped. Some R layers can be ripped with heavy power equipment. The bedrock may contain cracks, but these are so few and so small that few roots can penetrate.

**Soil layers** are more or less parallel to Earth's surface. Each horizon contains one or more properties, occurring over a certain depth, which characterizes it. The thickness varies from a few centimetres to several metres; most commonly it is about a few decimetres. The upper and lower limits or "boundaries" are gradual, clear, or abrupt. Laterally, the extension of a soil layer varies greatly, from a metre to several kilometres. However, a soil layer is never infinite. Laterally, it disappears or grades into another layer.

Now examine a soil profile. Do Activity 6.14.

### **Activity 6.14 Observing a Soil Profile**

#### **Materials**

- Part A: soft rock sample, sand paper or wire screen, pieces of old newspaper  
Part B: garden, notebook, crayons or colored pens, ruler

#### **Procedure**

##### Part A.

1. Rub the rock on wire screen or coarse sand paper for 10 minutes. Compare with other groups how much product you obtained.

##### Part B.

2. Find a place near your school or home where a soil profile is exposed. You may look for a quarry—a place where a hill has been cut for a road, a ditch, or a digging in the garden.



3. Do the following for each distinct layer.
  - Measure and record the height.
  - Determine the soil texture.
  - Note the colors of the soil layers.
  - Note if there is any rock and what type.
  - Note how far the roots of plants extend down.
  - Note any important features.
4. Make a sketch of what you see.
5. Look for any evidence that water is carrying minerals down through the profile.
  - a. How many distinct layers do you observe? Are the boundaries between layers sharp?
  - b. What is/are your basis/bases for dividing them into layers?
  - c. Explain why plant roots only extend to the depth you measured.

Soil that develops from weathering of the rock directly beneath it is called **residual soil**. Although this is a typical situation, a number of important agricultural regions have developed on **transported soils**, which did not form from the local rock but from parent material brought in from some other region. Transported soils usually form from sediments deposited by water and wind. For example, mud deposited by a river during times of flooding can form an excellent agricultural soil next to the river after floodwaters recede. The soil-forming mud may have been carried downstream from regions perhaps hundreds of miles away.

Most soils take a long time to form. This rate of soil formation is controlled by rainfall, temperature, and to some extent the type of bedrock that weathers to form soil. High temperature and abundant rainfall speed up soil formation, but in most places a fully developed soil that can support plant growth takes hundreds or thousands of years to form. What can you do to preserve and conserve soil?

## Soil Problems

Soil erosion has become a serious problem in many areas in the Philippines. Soil erosion in the Philippines is mainly caused by water. Heavy rains brought about by typhoons and monsoon winds result in large amounts of water flowing on Earth's surface (runoff). Large amounts of sediments are scraped from the land by runoff and carried into the rivers and eventually into the sea.

Soil erosion that occurs at about the same rate as soil formation is normally a harmless natural process. It may be beneficial for low areas

with no fertile soil. It forms beaches and caves for our recreation. But human activities that rapidly increase soil erosion upset these normal processes.

The destructive effects of increased soil erosion are now felt all over the country. Some of the major effects are loss of soil nutrients and topsoil to rivers or the sea; sedimentation of rivers, lakes, dams, and other water channels; and floods. The loss of soil nutrients deteriorates farmlands and forest lands. If the rich topsoil is washed away, it leaves behind barren subsoil. This reduces agricultural crop yield and trees cannot grow in rocky soil.

Soil acts like a sponge. It absorbs and stores water underground. Soil is held in place by the roots of trees. Trees and grasses slow down runoff so that water takes months to reach the lowland. Since water flows slowly, there is enough time for it to seep into the ground for storage as groundwater, and to become available to roots of plants. It takes about a year for all the water to be released from the soil. With the soil eroded and no trees to store water during the rainy season, wells dry up and springs disappear resulting in water shortage.

Bare rock left by soil erosion does not absorb much water. When a storm occurs, rainwater immediately flows to the lowlands causing floods.

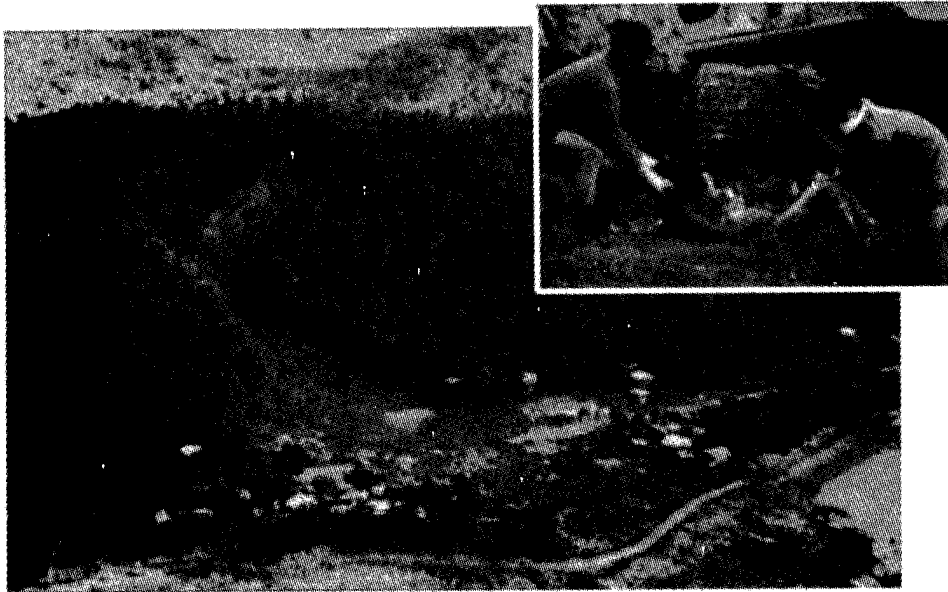
The two soil erosion control methods being applied in the Philippines are the preventive and the rehabilitative types. In slightly eroded areas, the preventive method is used. This method involves forest fire prevention, proper land use, correct range and forest management, proper road construction, and education of the people. The rehabilitative method is used in badly eroded areas. Its main objective is to restore eroded areas to their original condition. The method involves the use of vegetation (vegetative method) and engineering structures (mechanical method).

- Q6.19 What are some of human activities that enhance soil erosion?
- Q6.20 Make a consequence map when farmlands and forest lands lose their topsoil.
- Q6.21 Write an essay on flashfloods in the Philippines.
- Q6.22 Some of the rehabilitative methods used in controlling soil erosion are mentioned in Unit 5. Describe these methods: contour farming, cover cropping, terracing, and strip farming.

We depend on the soil for our existence. Most of our food comes from the soil. We have been using the wealth of our soil for many generations, yet we have been careless and have wasted much of our good land. If we are to survive, we must conserve our soil.

## Lesson 6.8 Mass Wasting

A news report before Christmas 2003 was disheartening. A devastating landslide occurred in eight barangays in Leyte (Figure 6.30). More than 5 000 families or 24 000 persons were affected by the catastrophe. About 170 persons were confirmed dead and hundreds were missing suspected to have been buried in mud (Inset of Figure 6.30). More than 600 houses were buried in mud or swept away to the sea.



*Figure 6.30 December 2003 landslide in Leyte*

In 1999, a landslide that happened in Cherry Hills, Antipolo claimed the lives of 60 people and left about 200 families homeless.

What are landslides? How do they happen? Can this be prevented? Landslide is the layman's term for mass wasting. In fact, there are many types of mass wasting and landslide is just one of them. **Mass wasting** is the downslope movement of unconsolidated rock, debris, or soil in bulk because of the pull of gravity with or without the aid of a transporting media like water. However, you normally hear of a landslide when there is heavy rain. Why is this so?

Weathering produces rock fragments and smaller particles. These are acted on by gravity. Because of friction or cohesive forces these are prevented from falling down. But if friction or any upward force is greatly reduced to balance the downward force of gravity, then the loose materials may fall, slip, or flow. This happens when the slope of the ground becomes very steep or when friction is greatly reduced by the presence of water in between particles. Remember that water can act as lubricant. Besides, water increases the weight of the loose materials

increasing the force of gravity on them. Roots of trees prevent loose materials from moving down. Thus, a slope without trees has a higher probability of having mass wasting. The type or structure of the surface also affects mass wasting. If cracks are parallel to the slope, then the rock fragments have a greater possibility to slide down than one in which the cracks are perpendicular to the slope. Earthquakes can also trigger all kinds of mass wasting.

Q6.23 Mass wasting is due to human activities. Consider Figure 6.31. What locations will probably undergo mass wasting? Why?

Q6.24 What do you think were the factors that led to the December 2003 Leyte and 1999 Cherry Hills mass wasting? Why do you say so?

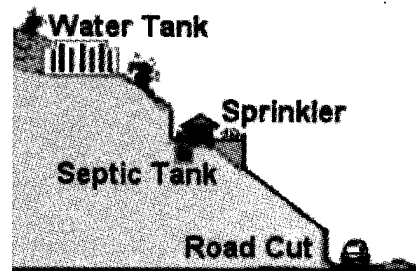


Figure 6.31 Human activities that enhance mass wasting

## Types of Mass Wasting

As human populations expand and occupy more and more of the land surface, mass-wasting processes become more likely to affect humans. Knowledge about the relationships between local geology and mass-wasting processes can lead to better planning that can reduce vulnerability to such hazards. Thus, we will look at the various types of mass-wasting processes, their underlying causes, and what humans can do to reduce their vulnerability and risks due to mass-wasting hazards.

**Rockfalls** occur when a piece of rock on a steep slope gets dislodged and falls down the slope. A rock fall can be a single rock or a mass of rocks and the falling rocks can dislodge other rocks as they collide with the cliff. **Debris falls** are similar, except they involve a mixture of soil, rock fragments, vegetation, and rocks. Because these occurrences (Figure 6.32) involve the free fall of materials, falls commonly occur where there are steep cliffs. At the base of most cliffs is an accumulation of fallen materials termed **talus**.

**Rockslides**, also called debris slides or landslides, occur when blocks of rock or masses of unconsolidated material such as soil slide down a slope ((Figure 6.33). These are among the most destructive of mass movements and may be triggered by rain, melting snow, or earthquakes. Water seeps between beddings and lubricates the slope. Piles of talus are common at the base of a rock or debris slide.

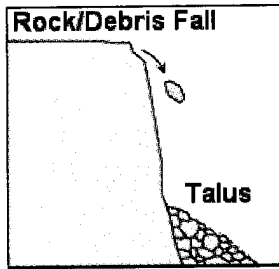


Figure 6.32 Rock and debris fall

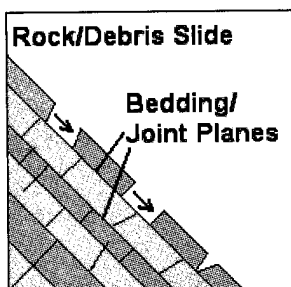


Figure 6.33 Rock and debris slide

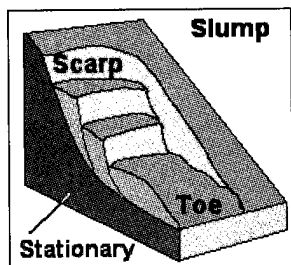


Figure 6.34 Slump

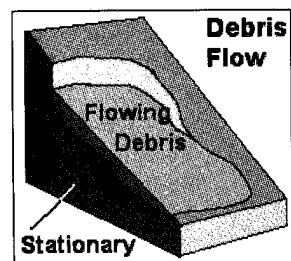


Figure 6.35 Debris flow

**Slumps** involve a mass of soil or other material sliding along a curved surface (shaped like a spoon). It forms a small, crescent-shaped cliff, or abrupt scarp at the top end of the slope (Figure 6.34). There can be more than one scarp down the slope. The top surface of each slump block remains relatively undisturbed. Slumps leave abrupt scarps or depressions on the hill slope. Slumps can be isolated or may occur in large complexes covering thousands of square meters. These are common along roads where slopes have been made very steep during construction, along riverbanks and sea coasts, where erosion has undercut the slopes. Heavy rains and earthquakes can also trigger slumps.

**Flows** are relatively common. Its shape is similar to a slump (Figure 6.35). They often occur at the toe of a slide since there is greater water that lubricates material and it flows. An earthflow is faster than a slump or creep but slower than a mudflow. These are usually associated with heavy rains. They usually remain active for long periods of time.

**Mudflow** has more water content than earthflow. The additional water increases lubrication so that in general they move farther and faster than earthflow. These fast-flowing high-density flows usually follow volcanic eruptions. Mudflow involving volcanic debris is termed lahar (Figure 6.36). Some lahars can be quite hot, if they are generated as a result of eruptions of hot tephra.

**Debris flow** is similar to mudflows, but with bigger pieces. Debris flows may travel with velocities of 15 to 50 km/h and involve rock fragments, most of which are coarser than sand.

**Debris avalanches** are very high velocity flows of large volume mixtures of rock and unconsolidated Earth materials that result from complete collapse of a mountainous slope. They move down slopes and can travel for considerable distances along relatively

gentle slopes. They are often triggered by earthquakes and volcanic eruptions.

**Creep** is the very slow, usually continuous movement of Earth materials down slopes, not directly observed. Creep occurs on almost all slopes, but the rates vary. Evidences for creep are often seen in bent trees, offsets in roads and fences, inclined utility poles, fence posts, and tombstones, broken or overturned retaining walls, and cracked foundations, sidewalks, and walls.



*Figure 6.36 Lahar*

- Q6.25 Arrange the mass wasting types according to speed—from fastest to slowest.
- Q6.26 Has there been mass wasting that happened in your locality? If so, what type is it? Why do you think it happened?
- Q6.27 With the development and changes going on in your community, what type of mass wasting is likely to happen?



*Figure 6.37 Retaining wall along Kennon Road, Baguio City is concrete poured over the exposed rock.*

Mass movements of debris can be prevented. When a hillside is altered by construction, some engineering solutions can be done. A retaining wall is usually built where a cut has been made in the slope. Some pour concrete over the exposed rock (Figure 6.37) or just cover the slopes with wire mesh to protect passersby from falling boulders.

- Q6.28 Retaining walls especially high ones have draining pipes put through them into hillsides. What is the purpose of these pipes?

Rather than making the slope very steep, the hillside can be cut back in a series of terraces rather than in a single step cut. Road cuts must be reseeded with rapidly growing grass or plants whose roots help anchor the slope.

- Q6.29 How does vegetation covering the hillside minimize erosion?

Before doing any alteration of the hillside in road construction, geologic studies of the area should be done to avoid hazard by choosing the least dangerous route for the road. If a road cut must be made through bedrock that appears prone to sliding, all of the rock that might slide could be

removed. The best solution in preventing mass wasting lies in educating the public so we can stay out of the worst areas.

## SUMMARY

Earth is a dynamic system. Earthquakes, volcanic eruptions, and mountain building can all be traced as due to the movement of the lithospheric plates. Plate movement is due to the convection of the hot and partially molten materials of the asthenosphere.

Land features built up by the plate motion are broken and torn down by the agents of weathering, erosion, and transportation which continually carve Earth's surface.

Due to Earth's dynamism, even rocks that make up Earth's surface undergo a cycle. And in the process of their formation and wearing away, minerals and soil are formed which are beneficial to humans.

## SELF-TEST

### I. Multiple-Choice Items

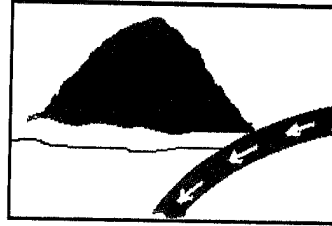
Choose the letter of the correct answer.

1. Why does Earth's size remain the same in spite of the movement of plates away from each other at oceanic ridges?
  - a. The edges of continents are maintained.
  - b. It is composed of continental and oceanic crusts of constant sizes.
  - c. Creation of crust at divergent margins is balanced by destruction at convergent margins.
  - d. What happens at oceanic ridge merely shakes the ocean waters and does not cause these to rise to increase the size of earth.
2. Most rocks found near Mt. Mayon are classified as igneous rocks because
  - a. rocks undergo frequent shaking due to earthquakes.
  - b. rocks are constantly heated by hot springs.
  - c. rocks solidified from magma.
  - d. all of the above.
3. A white rock when exposed turns reddish brown. Which statement best explains what happened?
  - a. Dirt covered the rock.
  - b. Oxygen reacted with the rock.
  - c. Heat from the sun burned the rock.
  - d. Water washed away all other minerals except those that are reddish brown.

4. Why is it not advisable to place a climbing vine against a concrete wall?
- The vine can hold water and wet the wall.
  - The vine can cause the breaking of the wall.
  - The vine can cover the structure of the wall.
  - The vine cannot absorb water and nutrients from the wall.

5. When continental and oceanic plates collide, the oceanic plate dives down under the continental plate as shown. Which statement best explains this observation?

- The continental plate exerts pressure on the oceanic plate.
- The oceanic plate is denser than the continental plate.
- The weight of the continental plate pushes down the oceanic plate.
- The top portion of the oceanic plate is wet so it tends to slide down the continental plate.



6. Planting near the edge of a mountain produced good harvest. Which of the following statements can be used to explain such observation?
- There is plenty of water in the place.
  - The mountain shields the plants from strong winds.
  - The mountain shields the plants from scorching heat of the sun.
  - Substances from weathered mountain rock materials supply nutrients to plants.

## II. Open-ended or Constructed - Response Items

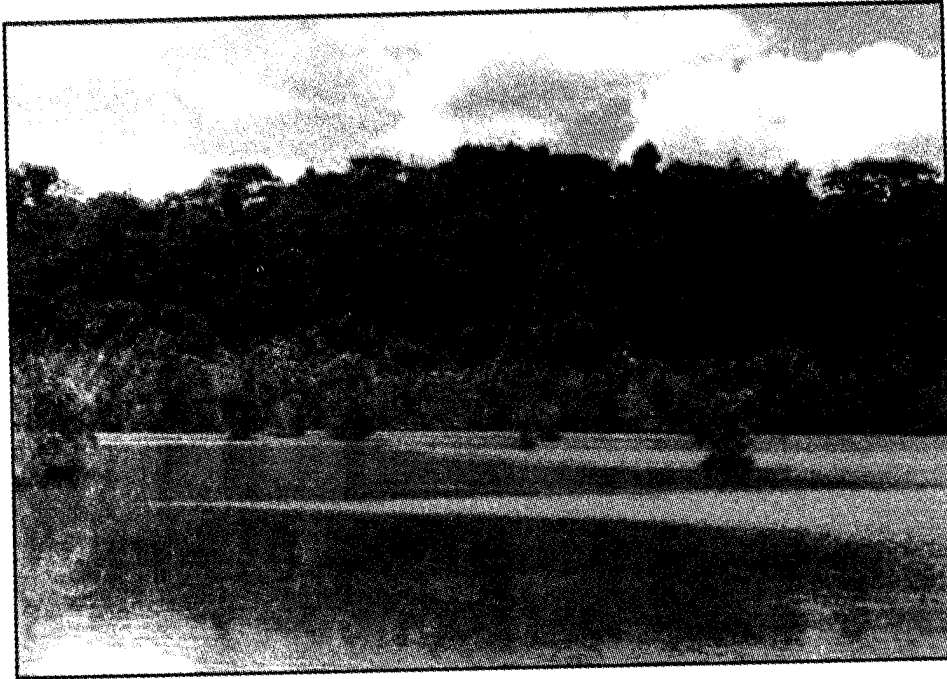
Answer the following.

- Which is thicker, (a) the Earth's crust or the lithosphere? (b) the mantle or the mesosphere? Why do you say so?
- What is the effect of plate movement on:
  - the surface features of Earth?
  - the evolution and diversity of animal and plant species?
  - the diversity of mineral resources in different places?
- What are the effects of plate tectonics on the Philippines' land features and mineral resources?
- Where does mass wasting usually occur? What conditions increase the probability of its occurrence?
- Describe some ways we can conserve our (a) mineral and (b) soil resources.



## Unit VII

### The Water Around Us



As far as we know, Earth is the only planet in our solar system where water exists as a liquid. What would your life be without water? Water constitutes about 70% of the mass of the human body. The brain is composed of 70% to 75% water, the blood 82%, and the lungs nearly 90%. If your mass is 50 kg, about 35 kg of your body is water. In terms of volume, you have about 35 litres of water in your body. You lose about 2.5 to 3 litres of water daily. You replace about 1.2 litres of the water you lost by drinking water; the rest of the lost water is replaced through the food you eat. Water represents as much as 95% of the mass of some plants and fruits.

Every tiny cell in your body contains water. Even the spaces between the cells contain water! Water carries nutrients and oxygen to the cells, helps protect organs and tissues, and removes wastes from the body. Water that evaporates from the skin's surface in the form of perspiration helps maintain the normal temperature of the body.

## Lesson 7.1 Water in Us

Let us look at the ways we use water. Consider a typical day:

- When you wake up, you are probably thirsty and you get something to drink. (A glass of water or juice perhaps?)
- Need to take a bath? Cook food? Wash the dishes and cooking pans? You cannot do all these without water.
- Water the plants? This takes so much water to accomplish.
- Time to get dressed? Of course water was used in washing your clothes. Water was also used in making the cloths for these clothes. The same with your beauty products, even your shoes and bags.
- Off to work, school, or play? How do you get there? Car, bus, train? Think about the fuel, motor oil, and machine parts and you'll realize that water was involved in all these.

Q7.1 Describe some of the ways the human body uses water.

Water provides waterways for the thousands of boats and barges that transport goods to different parts of the world. It is the most important means of communication between continents and between countries. Falling water provides energy for light and power. Water provides recreation for millions of people who love bathing, swimming, fishing, boating, and sailing, and other water sports. Too much or too little of water, in the form of rain, spells abundance or lack of crop harvests, and this would spell the difference between life and death to millions of people. Water is intricately involved in just about every process on this planet in one way or another. Water rules!

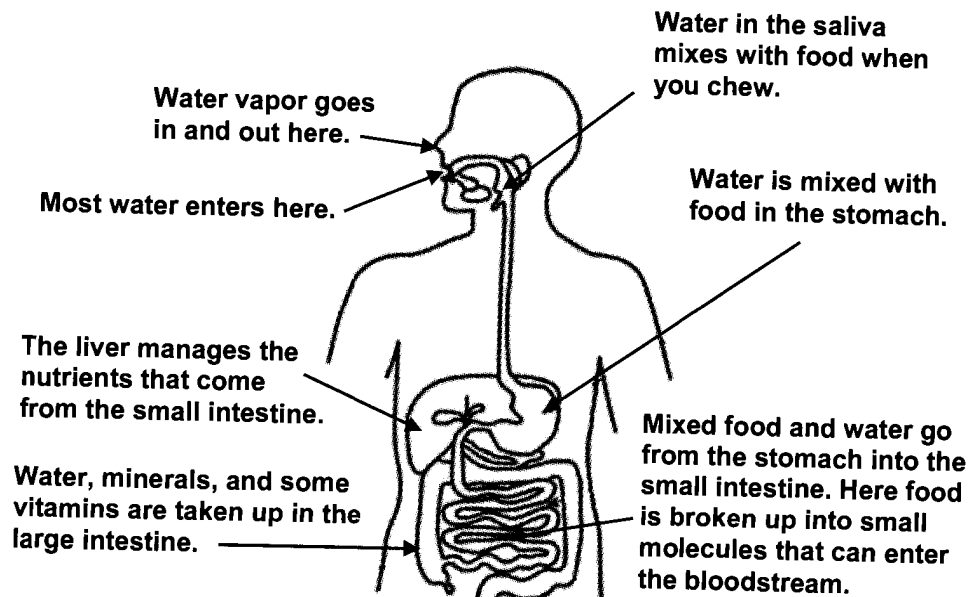
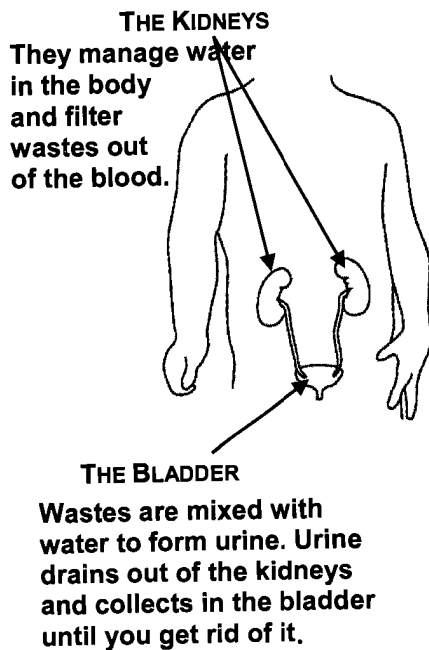
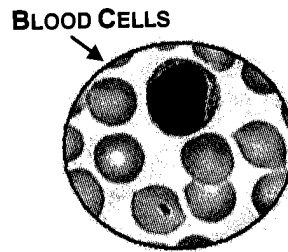


Figure 7.1 Different ways your body uses water



Water is in every tiny cell of your body. The blood is mostly water.



Water is in tears and in perspiration.

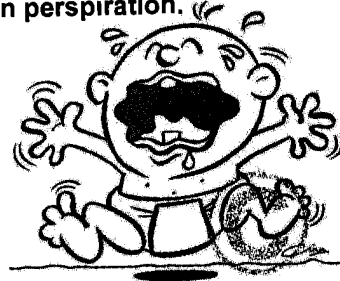


Figure 7.2 Water in the body

## Lesson 7.2 Waters of Earth

As the saying goes... "water, water, everywhere," how much water is really there? Where is this water? How does it move around? This section tells you where, how much, and in what forms water exists on Earth.

Water is the most abundant, most widely distributed, and most commonly used of all chemicals. How much of Earth's surface is water? Get a globe or world map. Look at the bodies of water—the seas, oceans, rivers, and lakes. Which is bigger, the water part or the land part? You will compare the various amounts of water in different areas in Activity 7.1. This is a simulation activity.

### Activity 7.1 Waters of Earth

#### Materials

7 pcs of 2 litre transparent bottles  
blue food color  
graduated cylinder  
medicine dropper

water  
marking pen  
masking tape

### Procedure

1. Label the bottles with numbers 1 to 7.
2. Fill Bottle 1 with 2 litres of water. Add 10 drops of blue food color. Describe the color of the resulting liquid.
3. Fill Bottles 2 to 6 with the corresponding volume as shown in the data table below. Observe closely the content of each bottle. Compare the amount and height of water in each.
4. Make a bar graph or a pie graph to show the comparative percentage of water in different forms.

Type of Water (1)	Percentage of Earth's Water Supply (%) (2)	Volume of Water to Use in Bottle (mL) (3)
All of Earth's water	100.0	Bottle 1:
All of Earth's saltwater (oceans)	97.5	Bottle 2:
All of Earth's freshwater	2.5	Bottle 3:
Freshwater locked up as glaciers and snow cover	1.73	Bottle 4:
Underground fresh- water	0.75	Bottle 5:
Surface freshwater	~ 0.0075	Bottle 6:
Water in soil and air	~ 0.0195	Bottle 7:

- a. Compare the contents of Bottles 1 to 7.
- b. Relate the contents to the type of water in Column 1.
- c. Describe the graph that you have constructed.
- d. Which type of water is present in greatest amount on Earth?
- e. Where do you generally find the least amount of water?
- f. Based on the above data, how will you explain the old saying "water, water, everywhere but not enough to drink?"

### The World's Water

You can tell from a world map or a globe where the largest amount of water on Earth is stored. Most of it is held in oceans and seas. Oceans and seas cover about 71% of Earth's surface.

The four great oceans are the Atlantic, Pacific, Antarctic, and Arctic. The seas, bays, gulfs, and straits that adjoin land form the edges of the oceans. Inland waters like rivers and lakes flow into seas and oceans. Together they all form one continuous body of water.

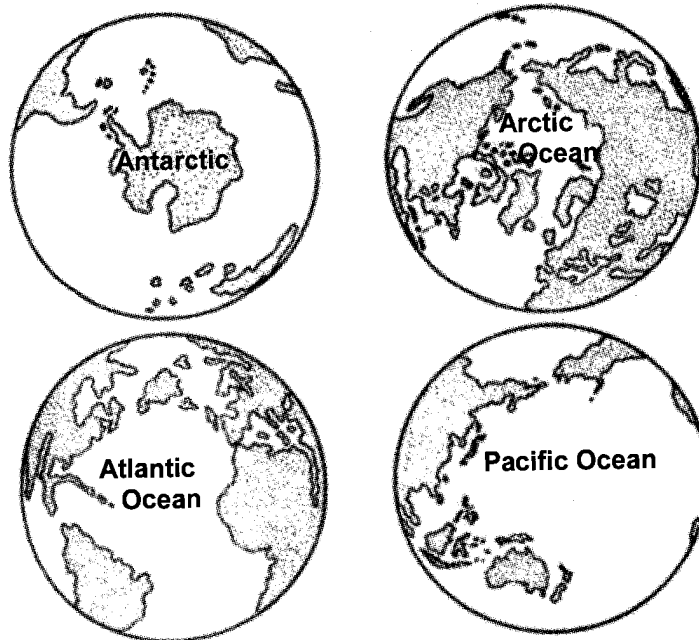


Figure 7.3 The four great oceans of Earth

When viewed from an ocean beach, the quantity of water seems limitless, but in reality, it is just a thin film covering portions of the planet. The average depth of the oceans is only about 3.5 to 4.0 km. But why is it that oceans never run out of water?

Earth is estimated to have a total of about 1.4 billion  $\text{km}^3$  of water. About 97.5% of this water fills the oceans and seas. The remaining 2.5% is freshwater. Of this 2.5%, 69% is in the form of glaciers and permanent snow cover, 30% is found under the ground, 0.3% constitutes the renewable freshwater in lakes and rivers, and 0.9% is in soil moisture, swamps, and in the atmosphere. **Glacier** is hardened ice found in the Polar Regions and on very high mountains. It has the largest amount of stored freshwater. Water in the atmosphere is found in the form of vapor (gaseous), or liquid or tiny bits of solid ice commonly called **ice crystals**. The amount of water in the atmosphere varies with latitude. It is greatest at the equator and least at the poles.

- Q7.2 Of the available freshwater, how much is in solid form or ice and therefore not available for human use?
- Q7.3 How much is Earth's supply of groundwater? Is it easily available to all living things including people? Explain your answer.
- Q7.4 How much water do we have for all our needs?

## The World's Water

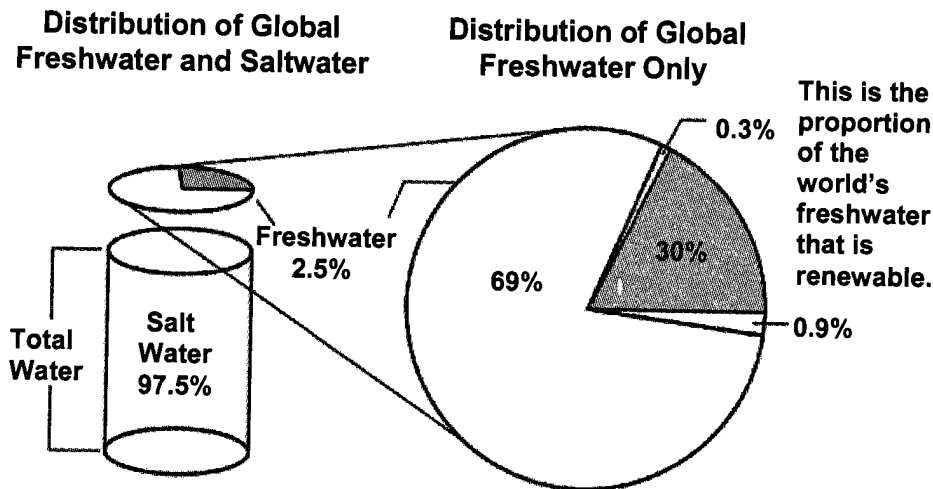


Figure 7.4 Of the world's water, 97.5% is salty and only 0.3% is freshwater that is renewable.

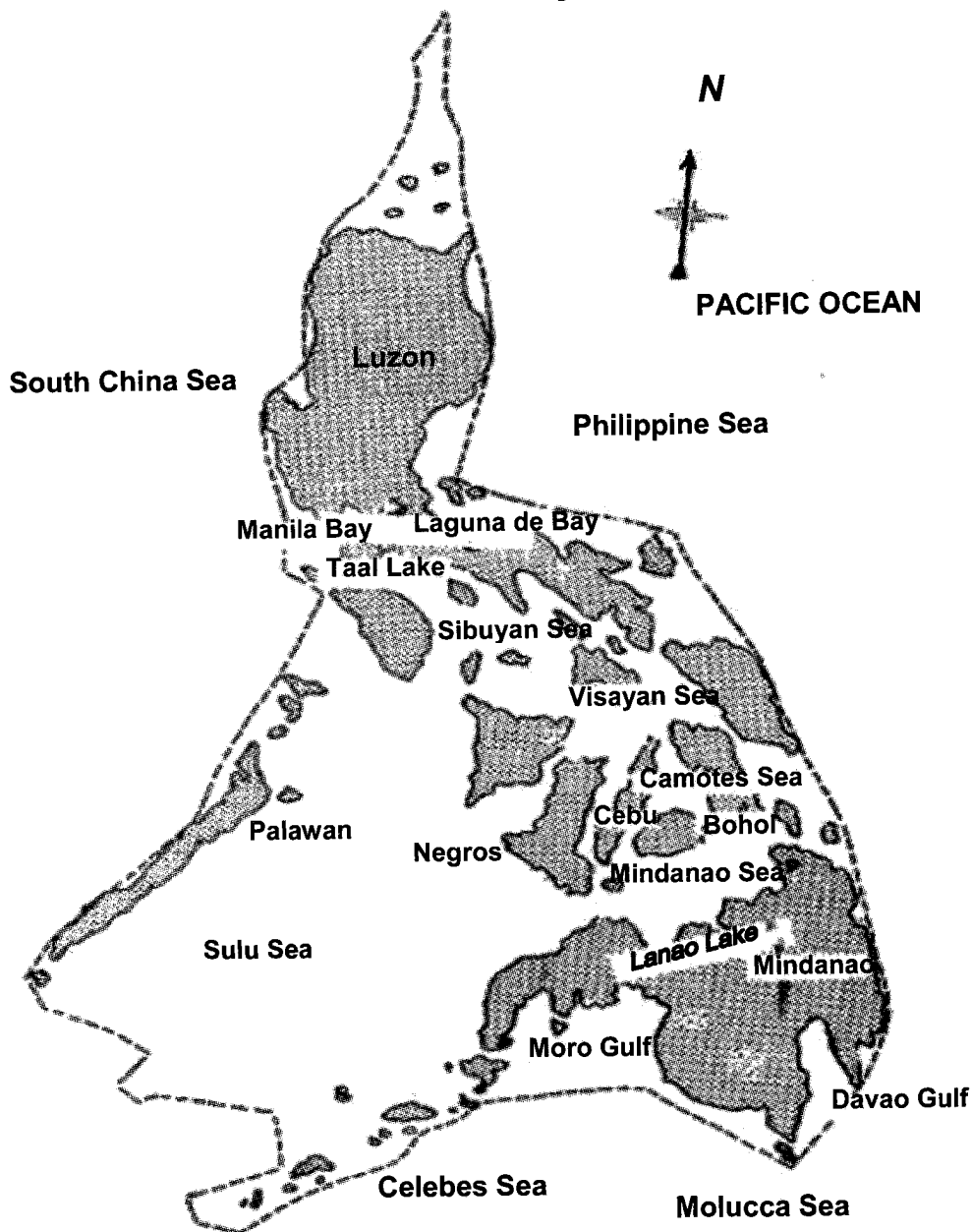
## Our Country's Territorial Waters

Water in the Philippines is well distributed but mostly is held in the oceans and seas within its national boundaries. The Philippines is an archipelago, a close group of islands surrounded and separated by oceans and seas. Within the islands are many lakes and rivers, most of which are too small to be shown in a small map. Let us study the location of waters in our country in Figure 7.5.

- Q7.5 Name the bodies of water found on the following boundaries of the Philippines: a) eastern, b) western, and c) southern.
- Q7.6 What is the largest sea found between islands in the Philippines?
- Q7.7 What sea is surrounded by
- the islands of Mindanao, Negros, Cebu, Bohol, and Leyte?
  - the islands of Panay, Negros, Cebu, Leyte, and Masbate?
  - the islands of Palawan and Mindanao?
- Q7.8 What is the largest lake in (a) Mindanao? (b) Luzon?

The territory of the Philippines extends to many kilometres of water around it. The territorial boundary known as the Philippines International Treaty Limits was set by the Treaty of Paris in 1898 when Spain surrendered the Philippines to the United States. The same territorial boundary was adopted by the Philippines in its 1935, 1973, and 1987 constitutions.

## International Treaty Limits



*Figure 7.5 Philippines territorial waters*

After examining Figure 7.5, which do you think is bigger, the surface area of water within the Philippines territorial limits or the surface area of land? The water area in the Philippines is about five times the land area. Although this water is mostly saltwater, we still get a good supply of fresh rainwater from it. Our location in the tropical region provides us with an abundance of energy from the sun that powers evaporation which, in turn, hastens cloud formation and rains. This entire process forms part of what is known as the water cycle. Let's do a simple activity to observe at close range the processes that occur during the water cycle.

## Endless Merry-Go-Round

Could you be drinking the same water that your great grandparents drank a hundred years ago? What do you think? Is the water we have on Earth today the same water that was here millions of years ago? Is the amount of water now the same as when the dinosaurs roamed our planet? Perform Activity 7.2 to see how the processes in the water cycle can go on continuously in nature.

### Activity 7.2 The Water Cycle

#### Materials

2 equal-sized transparent bottles	1 pc plastic sheet	rubber band
medicine dropper	2 thermometers	water
	blue food color	

#### Procedure

1. Label the bottles with numbers 1 and 2.
2. Half-fill each bottle with water. Add about two drops of blue food color to each bottle.
  - a. Describe the color of the resulting liquids.
3. Get the initial temperature of each liquid.
4. Cover Bottle 1 tightly with a plastic sheet. Secure the cover with a rubber band. Leave Bottle 2 uncovered.
5. Place the two bottles under the sun for about two hours then observe the setups. Are there any changes in the bottles?
6. Place a thermometer in the water for three minutes then read the final temperature of water. Do this simultaneously for the two bottles.
  - a. Compare the two temperatures you obtained.
  - b. Compare the contents of Bottles 1 and 2 after two hours and their temperatures.
  - c. Was there a change in the water level in Bottle 1? If so, what is the reason for the change? Describe the processes the water went through when it was placed under the sun. Compare with your observations in Bottle 2.
  - d. Draw diagrams of the changes undergone by water in each bottle. How do these relate to the water cycle in the environment?



What you have just observed about the states undergone by water is similar to what actually happens in the environment. Figure 7.6 illustrates the water cycle. Follow the arrows in the diagram to see how water moves from one place to another in different ways.

The water cycle is the only way that Earth can be continually supplied with freshwater. Thermal energy from the sun is the most important part of renewing our water supply.

The sun provides the energy to change liquid water from Earth's surface (oceans, lakes, etc.) to water vapor through evaporation. Trees and plants also lose water to the air through transpiration.

The water vapor is then carried by rising air. As the air cools, water vapor eventually condenses, forming tiny droplets in clouds. When the clouds meet cool air over land, precipitation (rain, sleet, or snow) is triggered, and water returns to the land or sea. Some of the precipitation soaks into the ground. Some of the underground water is trapped between rock or clay layers; this is called **groundwater**. But most of the water flows downhill as runoff (above ground or underground), eventually returning to the seas as slightly salty water.

Q7.9 Where can we trace the origin of water in the atmosphere?

Q7.10 How does water return to the surface of Earth?

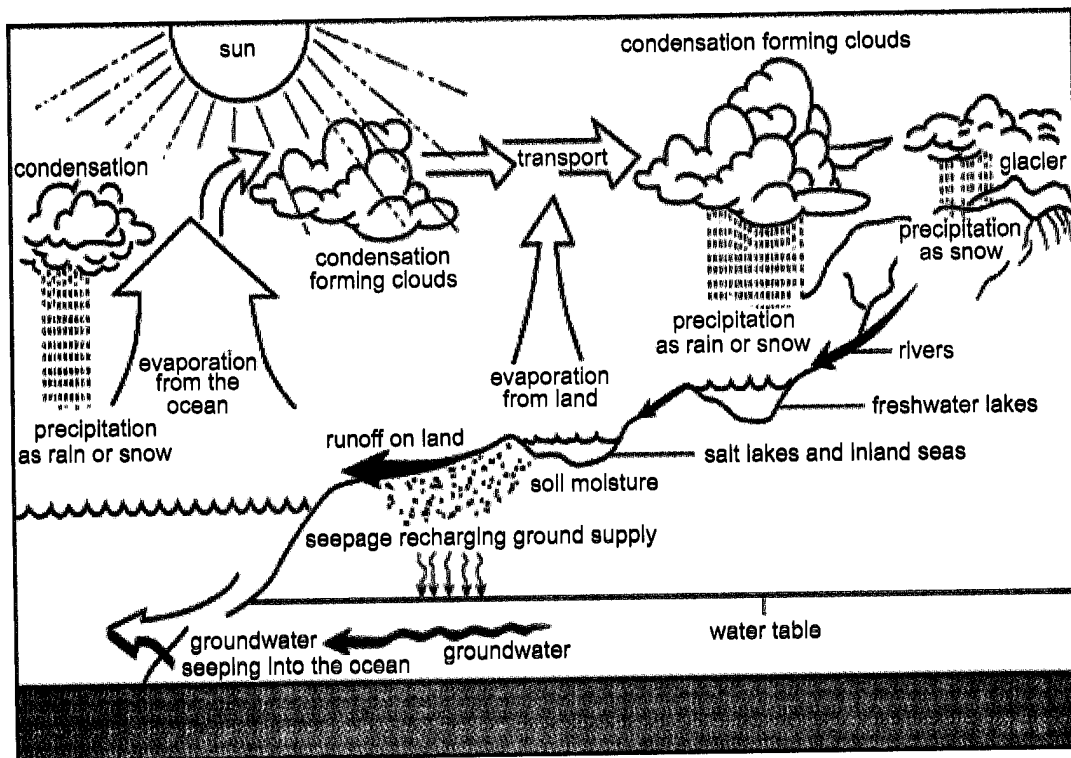


Figure 7.6 The water cycle

## Our Country's Inland Waters

Human settlements have tended to grow around inland bodies of water because of the freshwater they can get. Although very, very small, they are of great importance to humans and all forms of life. These inland bodies of water are mainly streams, rivers, lakes, and groundwater.

A **stream** consists of running water in a naturally formed channel which begins in an elevated area and usually ends in the sea or a lake. **Rivers** are permanent streams with flowing water throughout the year. **Brooks, creeks,** and **rivulets** are smaller channels of running water which may or may not be permanent (Figure 7.7).



*Figure 7.7 Marikina River in Marikina City*

A stream on a steep slope with fast flowing water forms a **rapid**. A stream dropping over a precipice or the vertical side of a mountain forms a **waterfall** (Figure 7.8). It is not difficult to imagine the effect of a slope on the velocity (speed) of water flow. Where would a stream flow faster—on a steep slope or a gentle slope?

The Philippines has over 700 principal rivers and perhaps over a thousand small rivers which may or may not connect with the principal rivers. The Cagayan River in North-eastern Luzon is the longest and largest. It begins as the joining of many small rivers where the Caraballo, the Mamparang, and the Sierra Madre Mountains meet in Nueva Viscaya. It flows northward crossing the provinces of Isabela and Cagayan and drains into the Babuyan Channel (Figure 7.9). The second largest is the combined Mindanao-Agusan Rivers in Northeastern Mindanao (Figure 7.10).



*Figure 7.8 Pagsanjan Falls in Pagsanjan, Laguna*

The location, size, and shape of inland bodies of water change through time as water wears away the land.

**Lakes** are large bodies of standing water (as compared to the running water of streams) held in deepened areas of land called **basins**. Some amount of water may be constantly flowing out and water from rivers may be constantly flowing in, as in the case of Laguna de Bay. However, to contain and maintain its water, a lake must have fewer outflows than inflow. **Ponds** are much smaller and shallower bodies of standing water than lakes. **Swamps** are generally wider than ponds or lakes but are shallower because of sediment deposited at the bottom. Swamps are usually overgrown with vegetation.

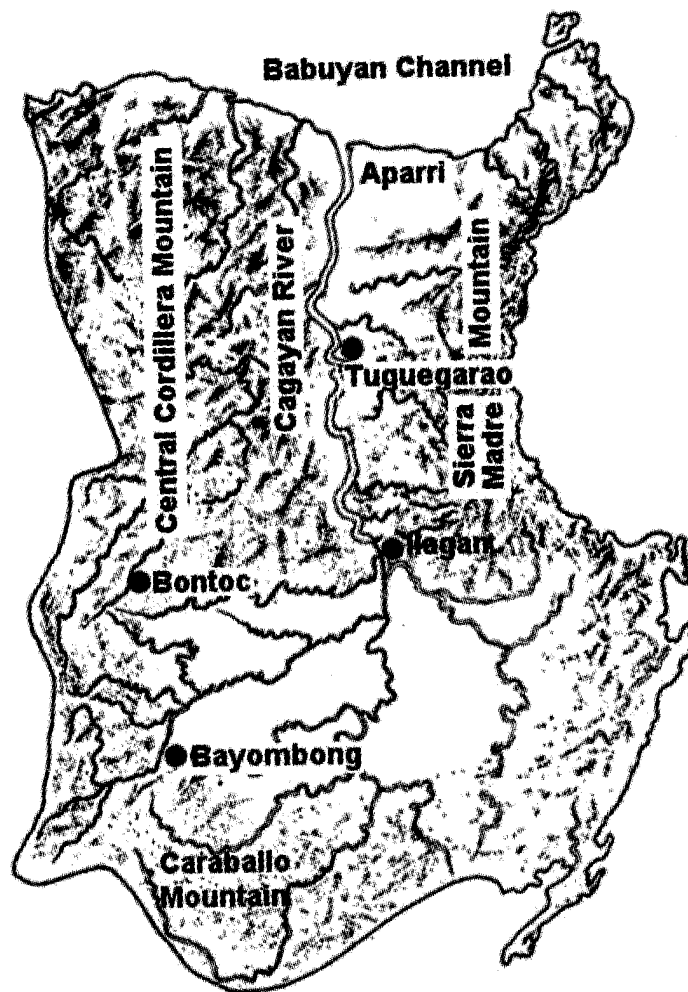
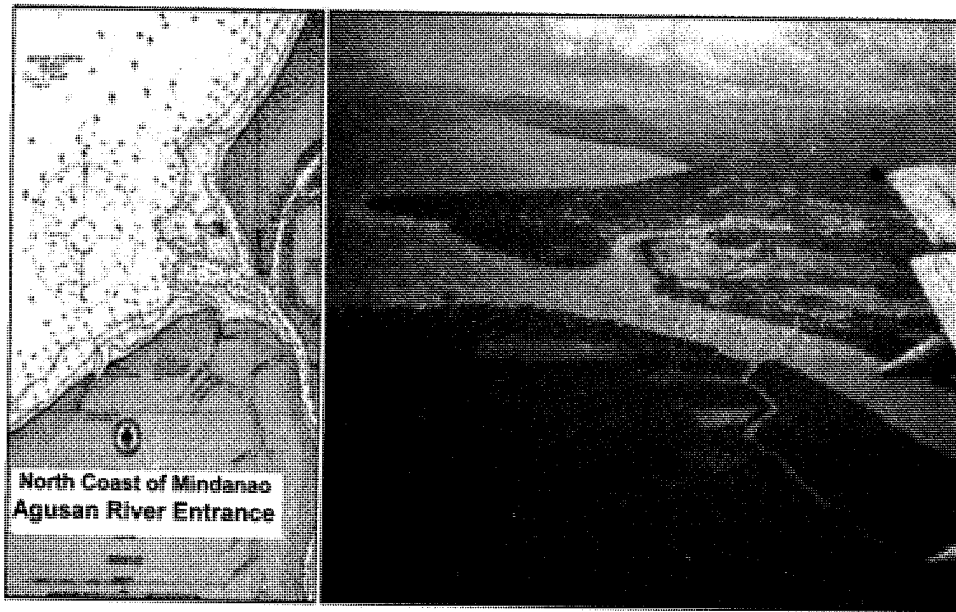
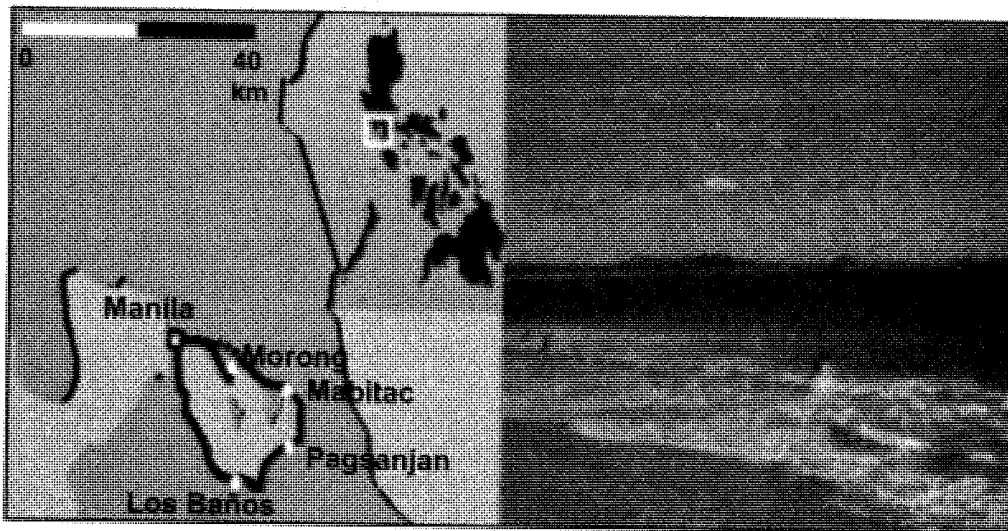


Figure 7.9 Cagayan River draining at Babuyan Channel



*Figure 7.10 Agusan River cuts through Agusan del Norte and empties into Butuan Bay, Mindanao.*

Of the 59 major lakes in the Philippines, the largest is Laguna de Bay (Figure 7.11) in Southern Luzon. Other well-known lakes in the country are Lake Lanao in Mindanao, Lake Taal in Southern Luzon, not far from Laguna de Bay, and Lake Bulusan in Sorsogon.



*Figure 7.11 Laguna de Bay in Southern Luzon*

Q7.11 Is it possible that the water you drank today may have contained the same water molecules that your great grandparents drank? Could they be the same water molecules that the dinosaurs bathed in? Why or why not?

## Lesson 7.3 The Properties of Water

What's so special about water? Pure water has no color, no taste, and no smell. It is one of the simplest chemical substances, made of just three atoms—two atoms of hydrogen (H) and one atom of oxygen (O). However, unlike other chemical substances, it is everywhere—in clouds, oceans, ice, steam, and even underground.

Water seems common, but you might be surprised to know just how uncommon it really is. No living thing—plant or animal—can survive without it. Without water, there would be no oceans, no lakes, no rivers, no rain, no snow, no clouds, no polar ice caps, no soft drinks nor juices, nothing to drink whatsoever, and probably no you, no me, no nothing! Water has a structure that seems common yet makes it uncommon to all other chemicals.

### Water Is a Polar Molecule

Water is a chemical compound with the chemical formula  $H_2O$ . The formula means that one molecule of water is composed of two atoms of hydrogen bonded to one atom of oxygen. The molecule is shaped like an isosceles triangle, with a slight bond angle of 105 degrees at the oxygen nucleus. The hydrogen atoms are smaller and they rest on both sides of the larger atom. Refer to Figure 7.12. The electrons of the hydrogen atoms are strongly attracted to the oxygen atom, and are actually closer to the oxygen's nucleus than to the hydrogen nuclei. Thus, the shared electrons spend more time closer to the oxygen side of the molecule.

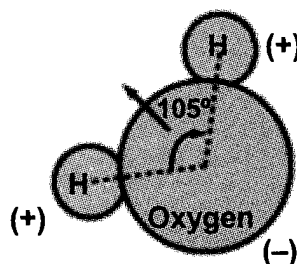


Figure 7.12 Structure of the water molecule

This uneven sharing of electrons results in the oxygen side having partial negative charge and the hydrogen atoms sides having partial positive charge. This forms the polar water molecule. A molecule with such a charge difference is called a **dipole**. The charge differences cause water molecules to be attracted to each other and to other polar molecules. This attraction is known as **hydrogen bonding**. Figure 7.13 shows the hydrogen bonding of water molecules in liquid water.

Hydrogen bonding in water is formed when the positively charged hydrogen atom of one water molecule is attracted to negatively charged oxygen atom of another water molecule. One molecule can form hydrogen bonds with four nearest water molecules. The fact that water molecules can form so many hydrogen bonds gives water its "sticky nature." These hydrogen bonds also give water many other uncommon properties.

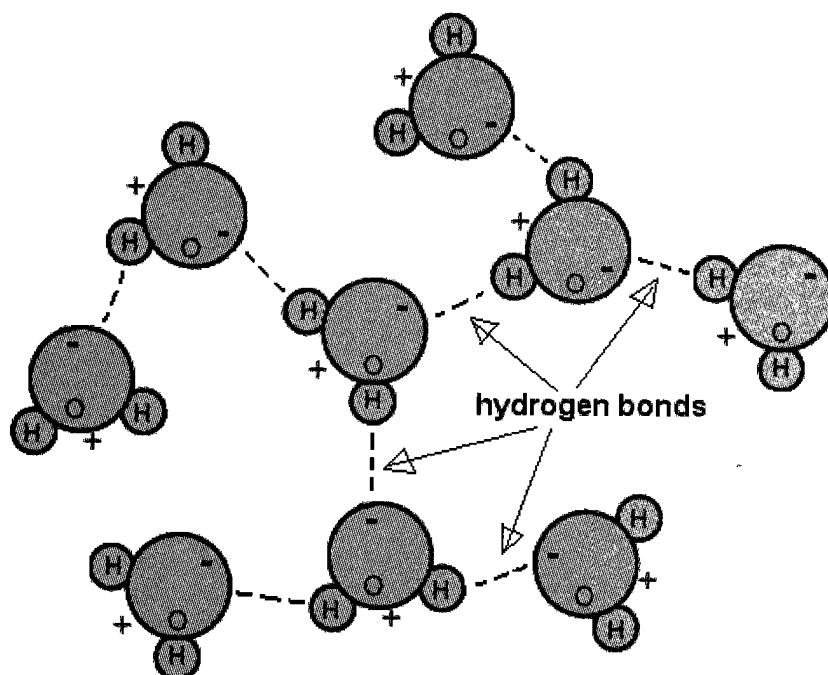


Figure 7.13 Hydrogen bonding in water

## Water Has a High Surface Tension

The ability of water molecules to break and reform hydrogen bonds explains why it has high surface tension. The hydrogen bonds enable water to exhibit high amount of cohesion making it "sticky" and set up a sort of "water barrier" that allows things like needle, toothpick, and blade to float on the surface of the water and causes water to form droplets. The relative strength of the hydrogen bonds allows insects to skate across the surface of the water without breaking. See Figure 7.14.

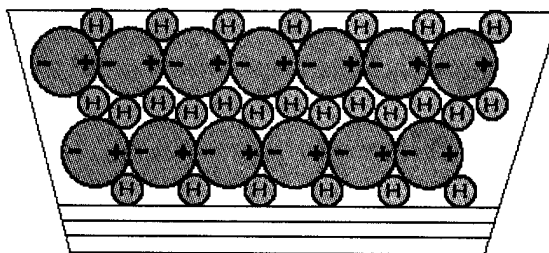


Figure 7.14 Surface tension in water

## Water Dissolves Almost Anything

You probably have observed how easily sugar and salt dissolve in water. What other materials dissolve easily in water? What materials do not? Find out the answers in the next activity.

### Activity 7.3 Water Mix-Mix

#### Materials

8 small, clear bottles	baking soda	vinegar
8 plastic tablespoons	waste cooking oil	table salt
marker pen	food coloring	ashes
leaves or wood chips		

#### Procedure

1. Label the bottles numbers 1 to 8. Do the same to the spoons. Assign one spoon to a bottle.
  - a. Describe the properties of water and all the materials given. Prepare a data table for your descriptions.
2. Half-fill each bottle with water. Bottle 1 will serve as the control. You will not add anything to it.
3. Add 4 tablespoons (tbsp) of vinegar to Bottle 2. Stir with a spoon. Observe the effect of the material on the observed properties of water. Enter your observations in Table 2.
4. Add 4 tbsp of waste cooking oil to Bottle 3, stir and observe.
5. Add 2 tbsp of table salt to Bottle 4, stir and observe.
6. Add 3 tbsp of baking soda to Bottle 5, stir and observe.
7. Add 2 tbsp of food coloring to Bottle 6, stir and observe.
8. Add 3 tbsp of ashes to Bottle 7, stir and observe.
9. Add 2 tbsp of leaves to Bottle 8, stir and observe.
  - b. Describe what happened when you stirred the contents of each bottle. Describe the contents of each bottle a couple of minutes after stirring.
  - c. Which solutes dissolved fastest in water?
  - d. Which solutes dissolved completely in water? Which did not? How were you able to tell?
  - e. Which observations showed that solutes can
    - change the color of water?
    - change the smell of water?
    - make the taste of water better? bad?
    - change the way water feels?
    - produce new materials with water?
  - f. Name some of the good and bad effects of the addition of substances to water.

You have seen that most of the solutes dissolved in water. Solids like table salt, food coloring, and baking soda dissolved in water. Liquids too, like vinegar and alcohol, dissolved in water. Some components of ashes and leaves also dissolved in water although slower and at a longer time. Cooking oil did not dissolve but instead formed a layer with water. Gases like carbon dioxide, oxygen, and ammonia dissolve in water. Carbon dioxide gas in the form of bubbles is released from newly-opened bottles of soft drinks and beer.

More substances dissolve in water than in any other liquid. The reason for water's excellent dissolving capability relates to its polar nature. Water offers positive and negative charges to which other atoms of molecules can attach. Opposite charges attract one another. The positive charges of water molecules attract the negative charges of other molecules; similarly the negative charges of water molecules attract the positive charges of other molecules.

Take note of how table salt (sodium chloride, NaCl) dissolves in water in Figure 7.15. In water, sodium chloride separates into charged particles of sodium and chlorine. Sodium, being positively charged, is pulled and surrounded by the negative side of the water molecules. At the same time, the chlorine, being negatively charged is surrounded by the positive side of the water molecules. The way the water molecules are arranged around any other atom or molecule leads to differences in water's ability to dissolve a substance. Hence, some things are easier to dissolve in water than others.

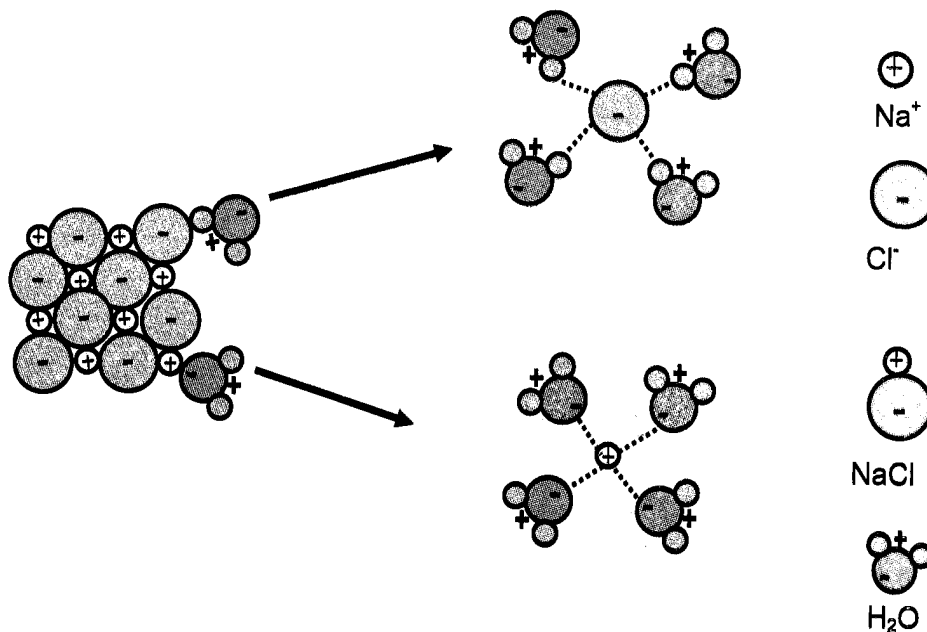


Figure 7.15 Sodium chloride dissolving in water



Another solid that water can dissolve easily is sugar. Sugar molecules also happen to be polar molecules, so the negative ends of sugar molecules are naturally attracted to the positive ends of water molecules, which will disperse the sugar and water molecules within a container. If you were to place a teaspoon of sugar into a glass of iced tea, and stir, the sugar would eventually dissolve, making each sip of tea sweet, not pockets of "sweetness" within the glass.

Water is never found pure in nature. Salts dissolved from rocks by water are carried by rivers to the sea. Therefore, river water, although called fresh, always contains some dissolved substances. Even rainwater is not pure because it dissolves gases as it falls through the air.

What does it mean when you hear the expression water is hard? This connects with the ability of water to dissolve many substances. Minerals that dissolve in water contribute to water hardness. Hard water contains a heavy concentration of minerals such as calcium, magnesium, and iron. It is characterized by soap which curdles and becomes an insoluble substance instead of producing lots of lather.

Many life processes happen because the needed substances dissolve in water and are transported to other parts of the body by water. Carbon dioxide from the air dissolves in water inside plant leaves for use in the manufacture of plant food. Oxygen from the air dissolves in oceans, seas, and lakes so that animals in water can absorb it in respiration. In the human body, oxygen in the lungs dissolves in the blood before it is carried to other parts of the body that need it. The food we eat must first be dissolved in the body liquids which are largely water before distribution to other parts of the body.

## **Water Has High Density**

Have you ever wondered why ice floats on water? Have you ever thought how different the world would be if ice didn't float? Ice floats because it is less dense than water. This is true about any two substances: if one is less dense than the water, then it will float. Examples are oil floating on water and logs floating on rivers.

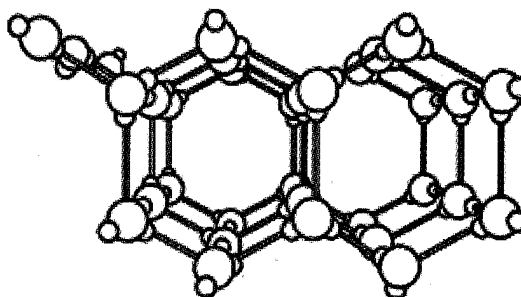
Water is one of the few substances that is less dense as a solid than as a liquid. While most substances contract when they solidify, water expands. This property is due to the hydrogen bonding.

The density of liquids and gases can change depending on temperature. In general, the densities of all liquids and gases increase when the temperature is decreased; the reason is that as the temperature is lowered, the energy of the molecules decreases. The spaces between molecules decrease so the molecules come near each other. The liquid or gas contracts. This is equivalent to saying that the volume of a mass

of the liquid or gas decreases as the temperature increases. The opposite is also true, that increases in temperature usually result in corresponding decreases in density.

Water is unique because it behaves differently. When it is above 4°C it behaves like other liquids; it expands and its density increases as it warms. It contracts and its density increases as it cools. It attains its maximum density of 1 g/cc at 4°C. The reverse happens as it cools further below 4°C. From 4°C to 0°C, the molecules begin to move less vigorously and start to expand. Its volume increases as it begins to form crystalline structures of ice (Figure 7.16). Increase in volume means a corresponding decrease in density. Thus, the density of water decreases as its temperature decreases from 4°C to 0°C. As the temperature reaches 0°C the water molecules become locked into a crystalline lattice with each water molecule hydrogen-bonded to the maximum of four partners.

Take note that at 0°C, the density of water is 0.9998 g/cc while that of ice is 0.9170. This means that a 9% increase in volume occurs when water freezes to ice. This explains why ice floats in water and why about 1/12 of the volume of a floating iceberg sticks out of the water. It also accounts for the bursting of water pipes and disintegrating rocks when water freezes during winter.



*Figure 7.16 Crystal structure of water molecules in ice*

The changes in density are of vital importance to the existence of marine life in lakes located in climates where the water temperature falls below 0 °C. As the surface water cools by contact with cold air, and to a lesser extent by evaporation, its density increases. This causes surface water to sink and warmer water rises to take its place. This process, referred to as **turnover**, goes on during the three or four autumn months in places with very cold climates. By the time the lake begins to freeze, most of its water has taken one or more trips to the surface. While at the surface, it dissolves some air and then, on cooling, carries this air back with it into the depths of the lake. This air is necessary if fish are to live in the water. If ice were heavier than water, even the deepest lakes would, in cold climates, freeze solid to the bottom. This, obviously, would destroy marine life.

The highly polar structure of water accounts for this unique behavior. As water cools, the energy of the molecules decreases. The tendency of the water molecules to come closer and become bonded to one another by hydrogen bonding increases.

## Water Has High Boiling and Melting Points

Water freezes (and melts) at 0 °C, boils (and condenses) at 100 °C.

Q7.12 Locate sulfur, selenium, and tellurium in the Periodic Table. To what Group do they belong? What other elements belong to the Group?

Q7.13 If the formula of the chemical combination of oxygen and hydrogen is H<sub>2</sub>O, which is actually water, what would be the formula of the combination of S and Se with hydrogen?

Water has abnormally high boiling point and melting point compared to hydrogen compounds with similar formula like hydrogen sulfide (H<sub>2</sub>S) and hydrogen selenide (H<sub>2</sub>Se). Both S and Se belong to the same group, VIA. The abnormalities are believed to be the result of the strongly polar character of the water molecule. Oxygen has stronger electron-attracting capacity than either S or Se, and so the consequent hydrogen bonding between water molecules is stronger. More energy is needed to break these bonds.

## Water Has High Heat Capacity

Water has a high heat capacity of 1 cal/g-deg. It has the highest heat capacity among the common liquids. This implies that it can absorb or release large quantities of heat without itself undergoing any significant change. Its temperature changes more slowly than those of other compounds that also absorb or release energy.

This resistance to sudden changes in temperature makes water an excellent habitat because organisms adapted to narrow temperature ranges may die if the temperature fluctuates widely. Also, because organisms consist mostly of water, they are more able to resist changes in their own temperatures.

It is this high heat capacity of water which makes it a widely used cooling agent in the cooling systems of engines and boilers and as a carrier of heat in hot-water house-heating systems and hot-water bottles.

It is this high heat capacity which modifies the temperature of a region near a large body of water and keeps it from changing suddenly and widely. For instance, when water in a large lake is warmed by the sun in the daytime even for a few degrees, it stores the heat that it absorbed throughout the day. At night, the heat from the gradually cooling water is transferred to the air, keeping the air warm throughout the night.

The heat capacity of water stems directly from its hydrogen-bonded structure. Although hydrogen bonds are weak, their combined effect is

enormous. When heat from the sun is added to liquid water, the energy is used to first break the hydrogen bonds, which allows the molecules to move freely. No change in state occurs. Water remains a liquid. Since temperature is a measure of the rate at which molecules move, the temperature of water rises slowly with the addition of heat. When the temperature of water drops slightly, many additional hydrogen bonds reform and release a considerable amount of energy in the form of heat.

## **Pure Water Has a Neutral pH**

Pure water has a pH of 7, which is neutral. Seawater with its dissolved minerals tends to be slightly basic, around 8 or 9.

Q7.14 Recall the materials you tested for pH in Unit III. Which of the materials were acidic? basic? What would be the effect of these on the pH of water when they are mixed?

## **Lesson 7.4 Density and Movement of Ocean Water**

What is the relationship between density and temperature? How does it relate to density current in bodies of water?

Leave a dish of water uncovered, that is, exposed to the air for some time, and soon the water disappears. If you place this dish of water directly under sunlight, the water even disappears faster. Why? Water absorbs energy from sunlight and becomes warm causing it to expand or increase in volume.

When heat is applied to a fixed mass of a substance, the volume of the substance increases so its density decreases. The substance becomes less dense because of the increased space that the same mass of the substance occupies. On the other hand, when the substance cools, it contracts as it gives off energy. Its volume decreases and consequently, its density increases.

The energy (solar) that is received by the surface of Earth is not equally distributed. The region near the equator receives more energy than the region near the poles. Once this energy is absorbed by the surface, it is transformed into thermal energy. This causes ocean water in the equatorial region to become warm (and less dense) and the ocean water in the polar region to become cold (and denser). This unequal heating likewise causes the rising and sinking of ocean water (Figure 7.17). The cold and denser water at the poles tend to sink and flow along the bottom, toward the equator. At the same time, warm water from the equatorial region flows along the surface toward the poles.

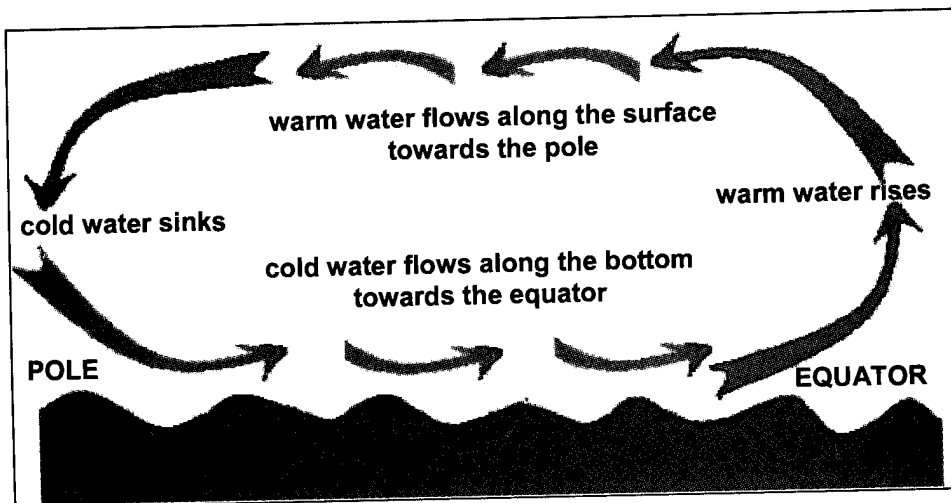


Figure 7.17 Water movement from the equator toward the poles.

The difference in densities that causes upward and downward movements in ocean water is known as **density currents**. Density current is one of the ways the waters of Earth move. In the past, people believed that currents were only on the surface and water at depths remained at the bottom. Factories dumped their wastes into the sea believing that wastes sank and stayed at the bottom. But now it is known that surface water sinks and bottom water, sometimes carrying solid materials, rises under certain conditions. Activity 7.4 demonstrates this idea.

### Activity 7.4 Simulating the Movement of Ocean Currents

#### Materials

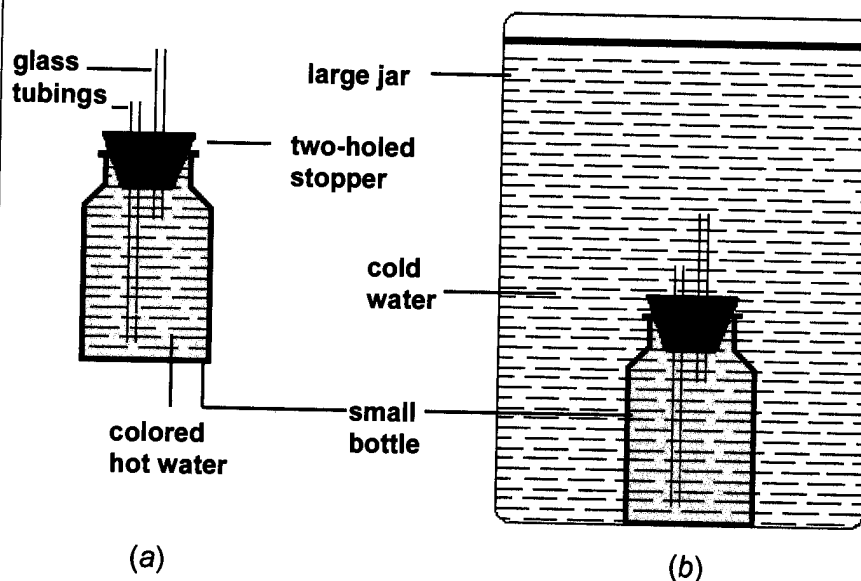
small clear glass bottle (about 30 mL capacity)	wooden stick
2 glass tubes (one long and the other short)	large glass jar
two-holed rubber stoppers	measuring cup
hot water	salt
	ink or dye
	cold water

#### Procedure

##### Part A

1. Fit the glass tubes into each hole of the rubber stopper as shown in diagram (a).
2. Add the dye to the hot water. Fill the small bottle with the colored hot water.

3. Prepare the setup as shown in diagram (a). The long tube should nearly reach the bottom of the small bottle and the short tube should reach just below the stopper.
4. Place the small bottle inside the large jar. See (b). Attach a plastic or rubber tube to the funnel. Using this funnel, fill the large jar with cold water until the small bottle is fully underwater.
  - a. What happened when the small bottle was placed in the large jar?
  - b. Which is denser—the water in the small bottle or the water in the large jar? Explain your answer.
  - c. Explain the movement of the colored and colorless water in the setup.



### Part B

5. Using the same setup, fill the small bottle this time with colored tap water.
6. Add half a cup salt into the large glass jar. Stir well to dissolve all the salt.
7. Complete the setup following step 4.
  - d. Describe your observations when the small bottle was placed in the large jar.
  - e. Explain the movement of the colored and colorless water in the setup.

The difference in the density of water also enables minerals and oxygen to circulate in the body of water. Oxygen from the atmosphere dissolves directly into the water. In very deep lakes, oxygen at the surface cannot reach the bottom when the surface water is warm. At the

same time, the minerals at the bottom of the lake cannot reach the surface. This situation continues for as long as the density of surface water remains low (Figure 7.18).

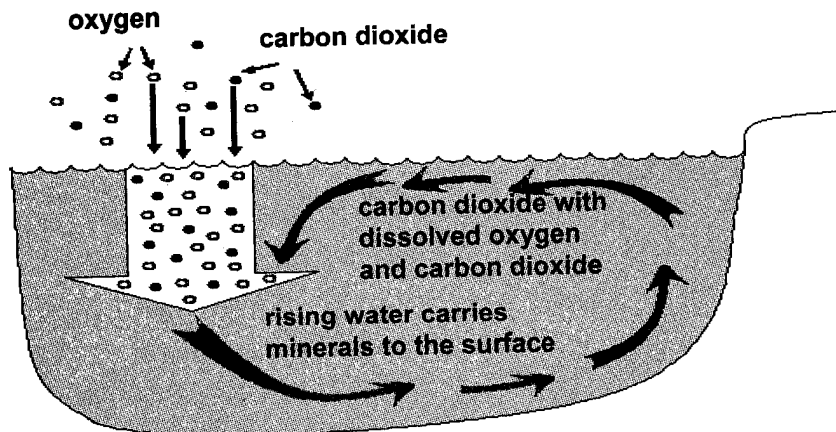


Figure 7.18 Circulation of minerals, oxygen, and carbon dioxide in a lake

It is to everyone's advantage that the density of surface water changes. When water at the surface cools off, it becomes denser and sinks. It carries with it dissolved oxygen. The oxygen is then used by plants, animals, and bacteria which live at the bottom of the lake. The bottom water is pushed up as denser water sinks. The bottom water also carries with it minerals as it rises. Plants and animals found near the surface then use these minerals as nutrients.

Q7.15 What will happen to a lake if the circulation of minerals and oxygen fails to occur?

## Lesson 7.5 How Pollutants Affect the Properties of Water

Is there a body of water near your house or school—maybe a lake or a river? If so, how do the members of your community use it? What is its condition now? Is it still colorless, odorless or is it now covered with water hyacinths or small green plants called algae? Do a mini-survey to find out more about the water in your community.

### Activity 7.5 Water in the Community

#### Materials

map of the province or city

**Procedure**

1. Take a map of the province where your home is located. Locate the street where you live. Identify the bodies of water around and within your province.
2. Prepare a data table similar to the one shown below. Mark with a check (✓) in Column 4 the activities common to Columns 2 and 3. Put X in Column 5 to indicate the activities that are different.

Body of Water	How You Use the Body of Water Today	How Your Grandparents Used the Body of Water	Similarities	Differences
(1) Surrounding the province a. b. c.	(2)	(3)	(4)	(5)
Within the province a. b. c.				

- a. Describe the body of water nearest your home. Ask your parents or old members of the community to give their observations of the same body of water during their younger days. Compare the observations.
- b. Which of the water-related activities you are doing now were also done by your grandparents when they were your age?
- c. If the bodies of water are used as fishing grounds, are they as productive as they were during your grandfather's time?
- d. What caused the scarcity of fish in the fishing grounds?
- e. Study Column 1. What are the kinds of bodies of water found in the province?
- f. Compare the uses of each kind. Classify them according to industrial, agricultural, and municipal (including domestic).

The Bureau of Fishery and Aquatic Resources has identified some of the reasons why fishing grounds are now less productive. Over fishing is one of the reasons. Commercial and municipal fishing activities have been concentrated in few selected fishing grounds near the land. Fish in these areas do not grow large and mature enough to hatch fingerlings. So instead of catching big fish, small ones are being harvested. Deep-sea



fishing is a good alternative but remains difficult to many small fishermen because of poor and substandard equipment.

The use of illegal fishnets (*sinamay* or fine-meshed nets less than 2 cm), illegal methods such as dynamite fishing, and fishing with a toxic chemical sodium cyanide have also been identified as causes for the decline of fish production in our fishing grounds. In some places, oil spills caused by oil tankers and boat accidents have added to the worsening problems.

Q7.16 What causes the reduction in fish productivity?

Inland waters are also good fishing grounds. Milkfish (*bangus*) fishponds abound in the country. But productivity of inland waters has also greatly diminished. Worsening pollution of rivers and lakes due to domestic, industrial, agricultural, and mining activities are destroying the natural spawning grounds of fish and other water organisms.

Q7.17 There are reports that freshwater fish, like the *kanduli* in Laguna Lake, *tabios* in Lake Buhi, and *maliputo* in Taal Lake, are now disappearing. Can you name some causes of this reduction?

Q7.18 What is happening to bodies of water in the country today? Look at Figure 7.19. Does the body of water in your area look like this river? Give some reasons why the river looks the way it is.



Figure 7.19 A polluted river

Unfortunately, many people are careless. They throw their wastes directly into bodies of water, thinking that the wastes will all be dissolved by water and carry them as they move along. They fail to understand that the solid and liquid wastes that they dump in drains or drop on the ground eventually end up in bodies of water. Rain washes these wastes from the streets into drains (e.g., underground pipes) and then into our streams, rivers, bays, beaches, and the ocean. These wastes end up in the places where we swim, go boating, or fish. Do you want to go swimming or fishing in a river full of wastes? Do you want your drinking water to come from this same dirty river?



Figure 7.20 Underground water pipes draining into a river

When water becomes unfit for its intended use, it is considered polluted. Water pollution occurs when a body of water is adversely affected due to the addition of large amounts of waste matter. These are called **water pollutants**.

Two types of water pollutants exist: point source and nonpoint source. **Point sources** of pollution occur when harmful substances are emitted directly into a body of water. The Exxon Valdez oil spill best illustrates point source water pollution. A **nonpoint source** delivers pollutants indirectly through environmental changes. An example of this type of water pollution is when fertilizer from a field is carried into a stream by rain in the form of runoff which, in turn, affects aquatic life. Aside from fertilizers, other materials that fall under this type are silt and other suspended solids such as soil, construction and logging sites, wastes from urban areas, and eroded riverbanks when it rains. Pollution arising from nonpoint sources accounts for a majority of the pollutants in rivers and lakes. See Table 7.1 for a classification of common pollutants and where they come from.

**Table 7.1 Classification of Water Pollutants and Their Origin**

<b>Pollutant</b>	<b>Where It Comes From</b>
Sediment	<ul style="list-style-type: none"> <li>• Dust and land surface erosion</li> <li>• Pavement and vehicle wear (tires, brakes, etc.)</li> <li>• Organic matter (e.g., leaf and food litter, grass, animal droppings)</li> <li>• Runoff water from washing cars</li> <li>• Weathering of buildings and other structures</li> </ul>
Nutrients	<ul style="list-style-type: none"> <li>• Organic matter (e.g., leaf and food litter, grass, animal droppings)</li> <li>• Fertilizers</li> <li>• Sewer overflows and septic tank leaks</li> <li>• Detergents (clothes and car washings)</li> </ul>
Oxygen demanding substances	<ul style="list-style-type: none"> <li>• Decaying organic matter (plants and animals)</li> <li>• Sewer overflows and septic tank leaks</li> <li>• Oil and gasoline spills</li> </ul>
pH (acidity)	<ul style="list-style-type: none"> <li>• Atmospheric gases</li> <li>• Decaying organic matter</li> </ul>
Toxic chemicals	<ul style="list-style-type: none"> <li>• Pesticides</li> <li>• Herbicides</li> <li>• Spillage and illegal discharges</li> <li>• Sewer overflows and septic tank leaks</li> </ul>
Heavy metals	<ul style="list-style-type: none"> <li>• Atmosphere</li> <li>• Vehicle wear</li> <li>• Sewer overflows and septic tank leaks</li> <li>• Weathering of buildings and other structures</li> </ul>
Increased water temperature	<ul style="list-style-type: none"> <li>• Cooling systems of boilers in electric-generating plants and manufacturing industries</li> <li>• Lack of surrounding vegetation</li> </ul>

## Lesson 7.6 The Dangers of Water Pollutants

### Pollutants

The major sources of water pollutants can be classified as municipal, industrial, and agricultural. Municipal water pollutants consist of wastewater from homes and commercial establishments. Industrial water pollutants consist of wastewater from manufacturing industries and power-generating plants. The characteristics of industrial waste-waters differ considerably depending on the kind of industry the waste came from. Agricultural water pollutants consist of wastewater from farms including commercial livestock and poultry farming. It also includes sediments from erosion of croplands. Show in a concept map how the factors affect each other.

What are the dangers of water pollutants? See the effects of water pollutants on plants in Activity 7.6.

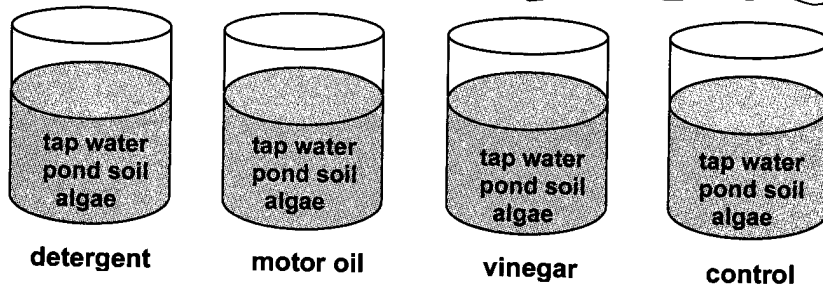
#### Activity 7.6 Effects of Water Pollutants on Plants

##### Materials

4 two-litre clear plastic containers	thread
water from an aquarium or pond (with some algae or aquatic organisms)	teaspoon
soil from a pond or gravel	wooden stick
used motor oil, cooking oil	vinegar
measuring cup	detergent
plastic bag	plant fertilizer
	cutter

##### Procedure

1. If you are using plastic containers, cut the upper portion (the mouth part) of each before using. Label the containers A, B, C, and D.
2. Fill the containers one-third full of aged tap water.
3. Add to each container two cups of pond soil or gravel from an aquarium. Then add pond water with algae or aquatic organisms up to almost the brim.
4. Dissolve four teaspoon (tsp) of plant fertilizer to a cup of water and mix well. Divide the mixture into four and add each to the four containers.



5. Add one-half cup of liquid detergent to Container A, one-half cup of used motor oil to Container B, and one-half cup of vinegar to Container C. Container D will be the control. Nothing will be added to it.
6. Cover the containers with a thin piece of cloth and tie loosely the edges. Put the containers near the window under indirect sunlight. Observe the setup every day for two weeks. After two weeks, compare the contents of the four containers. Prepare a data table for your observations.
  - a. Predict what will happen to the contents of the containers after two weeks.
  - b. Where in everyday life do you see the effects of water pollution like those in the containers?
  - c. How would you prevent these effects from occurring?
  - d. Compare the contents of the four containers after two weeks. Which pollutant had the worst effect on plants?
  - e. What should people do if these pollutants are present in water in huge quantities?

The experiment has shown that even ordinary materials like detergent and motor oil can have toxic effects on plants. The same can happen to animals. Different chemicals have varying effects on living things, whether plants or animals. Varying concentrations can be used as indicators of pollution because different species of organisms can tolerate certain levels of pollution.

Every class of pollutants has its own specific ways of entering the environment and its own specific dangers. All classes have major pollutants in it that are known to many people because of the various toxic effects.

### Organic Pollutants

Organic pollutants are compounds that contain the element carbon. Organic compounds are basic components of living organisms. Their effects toward living things (whether harmful or useful) depend largely on

their molecular structure, size, and shape. It is important to know the structure of organic compounds, in order to predict their fate in living organisms and the environment.

Organic pollutants enter waterways in many different forms: as sewage (industrial and municipal), as leaves and grass clippings, or as runoff from farms. When natural bacteria and protozoan in the water break down these organic materials, they begin to use up the oxygen dissolved in water (dissolved oxygen, DO). Many types of fish and animals that live at the bottom cannot survive when levels of DO drop below 2 to 5 parts per million. When this occurs it kills aquatic organisms in large numbers which lead to a break in the food chain.

There are many different types of organic pollutants, examples are:

- Hydrocarbons. This is a group of chemical compounds that contain carbon and hydrogen in their structures. Most of the fuels we use are made up of hydrocarbons like methane, butane, kerosene, and gasoline. Naphthalene and benzene are also hydrocarbons.
- Polychlorobiphenyls (PCBs). These are stable and unreactive fluids that are used as insulation fluids in transformers and plasticizers in paints. There are many different PCBs. None of them are soluble in water. In many countries PCBs are restricted.
- Insecticides such as DDTs are dangerous because they accumulate in fat tissues of lower animals and then enter the food chain. They have been restricted for decades.
- Detergents can dissolve in both water and oil because they can be both polar and nonpolar. The phosphates in them cause algal blooms in surface water resulting in the decrease of oxygen level in the water. This is called **eutrophication**. Oxygen starvation occurs because the microorganisms in water are unable to get oxygen which they need to live.

### **Inorganic Pollutants**

Some inorganic pollutants serve as nutrients so are not particularly toxic. But they pose danger to the environment because they are used extensively such as the fertilizers. The nitrates and phosphates in them cause eutrophication similar to the effects of detergents.

### **Metals**

Metals are natural substances that have been released through weathering of ore bodies, where they were deposited during volcanic action. They have been found to cause serious environmental damage. Examples of metals are: lead, iron, manganese, calcium, and potassium. They can be found in surface waters in their stable charged (ion) forms.

Unnatural metals can be very dangerous because they often come from human-made nuclear reactions and can be strongly radioactive. Metals can react with organic compounds to form lipophilic (lipo-loving) substances that are often highly toxic and can be stored in the fatty tissues of animals and humans. Metals cannot be broken down into less harmful components as they are nonbiodegradable.

Heavy metals are the most dangerous metals. They are lead, copper, zinc, and tin. They have a density greater than five and are therefore called **heavy**. All of them are extremely toxic to birds. Common sources of lead are lead paints, lead solders, and lead batteries. Zinc sources include galvanized wires, clips or staples, zippers, keys, plumbing nuts, padlocks, chrome, and some antirust paints, shampoos, and skin preparations.

### **Pathogens**

Pathogens can be very harmful. They can cause many illnesses that range from typhoid and dysentery to minor respiratory and skin diseases. Pathogens include organisms such as bacteria, viruses, and protozoa. These pollutants enter waterways through untreated sewage, storm drains, septic tanks, runoff from farms, and particularly boats that dump sewage. Though microscopic, these pollutants have a tremendous effect evidenced by their ability to cause sickness.

## **General Effects of Water Pollutants on Health**

Water pollutants can have many different effects on living things, always depending on the pollutant and the living thing in question. Here are the general effects that a pollutant can have.

*Toxic to genes (Genotoxicity).* Many materials that enter the body of an organism are known to cause damage to DNA. These materials are called **genotoxins** because of their toxic effect on the genes. Examples of genotoxins are aflatoxin and vinyl chloride.

*Induce cancer (Carcinogenity).* Several chemicals are **carcinogenic**, which means that they can induce cancer in the body of humans and animals. Carcinogenic pollutants can play a role in one or more of the stages of cancer development in an organism. They can act as inductors, promoters, or progressors. Some known and/or suspected carcinogens are asbestos, pesticides like chlordane and dieldrin, carbon tetrachloride, chloroform, and formaldehyde.

*Toxic to the nervous system (Neurotoxicity).* Some chemicals are toxic to the nervous system of organisms. Chemicals that cause neurological effects are called **neurotoxins**. The consequences can be uncoordinated muscle tremors and convulsions, dizziness, and depression.

*Damage to the reproductive system.* Pollutants cause reproductive failure due to damage to the reproductive organs.

## **Lesson 7.7 Removing Water Pollutants**

Are there ways of preventing water pollution? There are several ways by which we can minimize the level at which pollutants enter the rivers and lakes. Science also provides several ways of removing these and making the water fit for human consumption.

People are advised to stop throwing garbage directly into bodies of water. Act responsibly in disposing household chemicals. Remember that when matter is thrown into the water, it is never lost. Those that dissolve are unseen but may still be there in another form. The insoluble ones remain and make the water look ugly and dirty. Those that do not decompose like plastics, styrofoam, and aluminum cans may be carried to other places and clog the waterways. They may cause floods when the rain comes.

Another way to minimize pollution is to recycle materials whose production requires so much water or creates water pollution.

The government requires industries to put up wastewater treatment plants. The factories remove impurities like colored chemicals, dissolved toxic chemicals, and suspended solids before they are disposed into the waterways. Even the hot wastewater is cooled first before it is thrown away. Hospitals should have wastewater treatment plants that remove harmful bacteria and viruses before they are thrown into the waterways.

Municipal water treatment plants utilize several processes before they discharge water to the water users. The basic method involves removal of suspended particles, aeration, flocculation, sedimentation, and chlorination.

Water can be further purified for consumption by making it undergo additional processes. The most common yet efficient is distillation but it is expensive because it uses much water and electricity. Ozonation is another method of disinfecting water using ozone gas. Ion exchange is used to remove inorganic pollutants which cannot be removed by filtration or sedimentation. It can remove hardness in water as well as other toxic chemicals like arsenic, chromium, excess fluorides, and nitrates. Reverse osmosis can effectively reduce sediments, dissolved solids, toxic metals, asbestos, and certain microorganisms.

Pollution of seas and oceans are more difficult to control because oil spills from accidents suffered by boats and ships are the common sources. How can oil spills be cleaned? Do the next activity to try out some of the methods.

## Activity 7.7 Ways of Cleaning Oil Spills

### Materials

plastic basin	chicken feathers
water	rags or tissue paper
used motor oil	dishwashing detergent
paper plate	3 hard-boiled eggs
wooden stick	rubber bands
hypodermic syringe	

### Procedure

#### A. Using feathers

1. Fill a basin half-full of water. Pour used motor oil enough to cover the water's surface.
2. Place the feathers in the water. Leave the feathers in the oil for about 10 minutes. Try to push the feathers into the water.
3. Remove the feathers after 10 minutes. Note down the changes in the feathers. How will you remove the oil from the feathers?
4. Wipe the oil from the feathers with rags or tissue paper. Describe what happened to the feathers afterwards.
  - a. What happened to the feathers when it was placed in water covered with oil?
  - b. How much oil do you think was removed? Can wiping with rags or tissue paper remove oil?
  - c. What do you think is the effect on birds that come into contact with oil spills in oceans and seas?

#### B. Using hard-boiled eggs

5. Put the three hard-boiled eggs (with shells on) into a basin with the oil-water mixture.
6. Remove one egg from the basin after 20 minutes. Remove another egg after another 40 minutes, and then the third egg after 1 hour. Describe the appearance of the three eggs.
7. Carefully wipe the eggshells with rags or tissue paper. Describe what happened to the eggshells.
8. After wiping the oil from the eggs, crack and remove all the eggshells. Observe closely the egg whites. Did oil get into the egg?



- d. Can wiping the eggs with rags or tissue paper remove oil? Compare the results of wiping on feathers and eggshells.
- e. Did oil get through the eggs? Explain your answer.
- f. If oil got through the eggs, can it be removed?

C. Using paper

9. Spread out tissue papers on the surface of oil in the basin. Keep the tissue papers there for about 5 minutes then remove them and spread out on a paper plate.

g. What is the effect of laying out tissue papers on the oil's surface?

10. Spread out a large rubber band on the oil's surface. Note down your observation. Compare them with those on feathers and tissue papers.

h. What is the effect of laying out a large rubber band on the oil's surface? Will removing oil with this method remove more oil?

11. Use a hypodermic syringe to remove the contained oil. How much of the oil was removed?

i. Can the hypodermic syringe remove most of the oil? What is the disadvantage of this method?

D. Using detergent solution

12. Add several drops of detergent dishwashing liquid into the remaining water-oil mixture in the basin.

j. Describe what happens to the oil.

k. Is detergent liquid another technique of removing oil?

l. Which of the methods is best for removing the oil? Which is best for keeping the oil in one place?

m. Although detergent solution can remove oil by breaking its surface tension, what other undesirable effect does it introduce into the water?

Oil pollution is a growing problem, particularly to coastal wildlife. Because oil is less dense and insoluble in water, the oil floats on water. Even small quantities spread rapidly across large areas of the water's surface to form a thin layer called **oil slick**. As the spreading continues, the layer becomes thinner and thinner, finally becoming a very thin layer called **sheen**, which often looks like a rainbow.

Oil spills can be very harmful to marine birds and mammals, and also can harm fish and shellfish. You may have seen pictures of oiled birds

that have been affected by oil spills. Oil destroys the water-repelling abilities of a bird's feathers, thus exposing these creatures to the harsh elements. Many birds and animals also swallow oil when they try to clean themselves, which can poison them. Depending on just where and when a spill happens, from just a few up to hundreds or thousands of birds and mammals can be killed or injured.

When there is too much oil on the water's surface, sunlight cannot penetrate the water layer. Plants in the water cannot manufacture food. Oxygen from the air cannot dissolve in water depriving the organisms of its oxygen supply. Fish are likely to suffocate and die. These organisms use up the limited oxygen for its decay. There are other ways of removing oil spills aside from the methods you have done in your experiment. Burning is one way but it is dangerous. There are mechanical methods of containing oil like the use of absorbents, skimmers, and barriers. Absorbents like sponges and feathers may be used to absorb oil but if widespread, will make the process tedious and time-consuming. Other absorbents are straw, hay, sawdust, corncobs or even volcanic ash.



*Figure 7.21 Workers use special nets to clean up the shore of oil spilled from an oil tanker.*

Skimmers use oil-attracting materials that can blot oil from the water surface. The oil is then squeezed out or scraped off into a tank. The use of dispersing agents like detergents is another method. Detergents break oil into tiny droplets and disperse them into the water where they are subjected to wave action and current which break down the droplets further. This helps to clear oil from the water's surface, preventing the oil slick from reaching the shoreline.

**Q7.19** Suggest ways to reduce oil spills from motorized *bancas* and other similar transportation facilities.

## Lesson 7.8 Community Problem Solving

Water quality should be every Filipino's concern. We know that good quality water in lakes and rivers as well as in seas and oceans encourages more fish and other living things to breed and thrive in them. We know that it is healthful to live near these bodies of clean water. Good quality inland waters are also the sources of water supply for drinking, cooking, cleansing, and domestic uses.

In the past, when water quality deteriorated people and animals simply moved to other areas with good water. But now with the rapidly increasing world population, it is becoming more difficult to find unoccupied areas with good quality water supply. The increasing number of people needing more water may result in more people speeding up pollution of water bodies. Many modern activities are leading to the destruction of water areas. It is not surprising then that water shortages now occur in many places in the country and the world. Industrial plants, mines, and cities should remove pollutants from wastewater before draining it into rivers and lakes.

How can you help conserve this very important resource? It is said that "two heads are better than one." In the next activity, try to suggest in an action plan what you can do to help solve water-related problems being experienced by your fellow community members.

### Activity 7.8 Action Planning for Community Problem Solving

#### Materials

town map and poster-making materials

#### Procedure

##### Part A

1. Draw a map of your town. Locate your residence and mark it on the map.

##### Part B

2. List some water-related problems that you have encountered in the community. Identify where these water-related problems are located and mark them on the map.

##### Part C

3. Study the list of water-related problems. Decide which problem needs to be addressed first. What is the basis for this answer?

4. Get a chart paper. Divide the paper into two columns. On the top, write the priority problem. On the left column list three questions and/or issues related to the problem while on the right column, the strategies you might use to address the problem.
5. Make an action plan. See the action planning matrix below.

Problem statement: \_\_\_\_\_

Desirable Change	Steps Required	By Whom	By When	Resources	Evaluation
1.					
2.					
3.					

6. Help organize and/or participate in the community campaign. For example, monitor and/or find ways to immediately improve the quality of a water body near your home or school.

We can all help in the care and conservation of the Earth's waters. Excessive use of water can be avoided in many little ways at home. Never leave tap water running while you soap and rub your hands or brush your teeth. Open it only when you are ready to use the water. Reuse water whenever possible. For example, water used in washing clothes can be reused for cleaning floors and toilets. Take care not to pollute bodies of water. Rivers and lakes should not be used as garbage and wastewater dumps.

In the large-scale use—industrial, municipal, and national—water conservation should be a policy. Treated sewage and wastewater released into bodies of water are less damaging than the untreated. Forests hold water longer in the ground, prevent flooding in surrounding lower areas, and supply water during the dry months. The denudation of forests reverses these effects. During the rainy months, water can be collected in human-made dams and reservoirs.

## SUMMARY

A large part of the earth's surface—about 70 to 75%, is covered with water. Similarly, water constitutes about 70% of the mass of the human body. It is present in the blood, in the lungs, and in every tiny cell of the body.

The Philippine territorial area is more water than land. The water surface within the national boundaries is five times as much as the land

surface. It is held mostly in oceans and seas.

Water is an indispensable chemical substance because of its unusual physical and chemical properties. The polar structure of the water molecules explains capillarity, surface tension, cohesion, adhesion, its ability to dissolve substances, and high heat capacity.

Water exists as a gas, a liquid, and a solid depending on its temperature. Its polar nature makes it a unique chemical compound. Its density decreases with decreases in temperature until 4 °C. Below this temperature, it exhibits the reverse, not shown by other chemical substances.

Water is never found pure in nature because of its unusual ability to dissolve different kinds of substances. Salts dissolved from rocks by water are carried by rivers to the sea. Therefore, river water, although called fresh, always contains some dissolved substances. Even rainwater is not pure because it dissolves gases as it falls through the air.

Water has a high heat capacity. It can absorb or give off large amounts of heat. The melting of ice and evaporation absorb heat. Freezing and condensation give off heat. It is this high heat capacity which modifies the temperature of a region near a large body of water and keeps it from changing suddenly and widely.

Ocean waters circulate as surface and density currents resulting in the exchange of water and its energy between the equatorial and the Polar Regions and between the surface and the bottom. Inland waters form lakes, ponds, swamps, rivers, and waterfalls.

Every individual should help in the care and conservation of Earth's waters to ensure the availability of good quality water for the use of the world's growing population.

## **SELF-TEST**

### **I. Multiple-Choice Items**

Choose the letter of the correct answer.

1. Which of the following would most likely happen if the density of surface water in the lake does not change?
  - a. Plants and animals at the bottom of the lake cannot go to the surface.
  - b. There will be continuous exchange of oxygen and minerals in the lake.
  - c. There will be lowering of the level of water in the lake.
  - d. All of the above.

2. Which is most likely the reason why oil spills floating on water kill aquatic forms of life?
  - a. Oil is poisonous to plants and animals.
  - b. Oil mixes with tissues of aquatic organisms.
  - c. Oil on the surface destroys plant tissues.
  - d. Oil cuts off the supply of oxygen.
3. What can we infer when drops of water are formed on the outside surface of a drinking glass with ice and water?
  - a. Water comes out of the glass.
  - b. Air comes out of the water in the glass.
  - c. Oxygen from air condenses on the outside surface.
  - d. There is water in the air in the form of water vapor.
4. Which of the following may directly pollute a body of water?
  - a. Oil wastes from a nearby factory
  - b. Dust and solid particles from the air
  - c. Mineral substances naturally dissolved in water
  - d. Gas exhausts from buses, trucks, jeepneys, and tricycles
5. Why do oil spills kill aquatic organisms?
  - a. The oil mixes with the water in the bodies of living organisms.
  - b. The oil is absorbed by the leaves and it affects photosynthesis.
  - c. The oil poisons the cells of plants and animals living in the water.
  - d. The oil covers the surface of the water preventing oxygen from getting into the water.

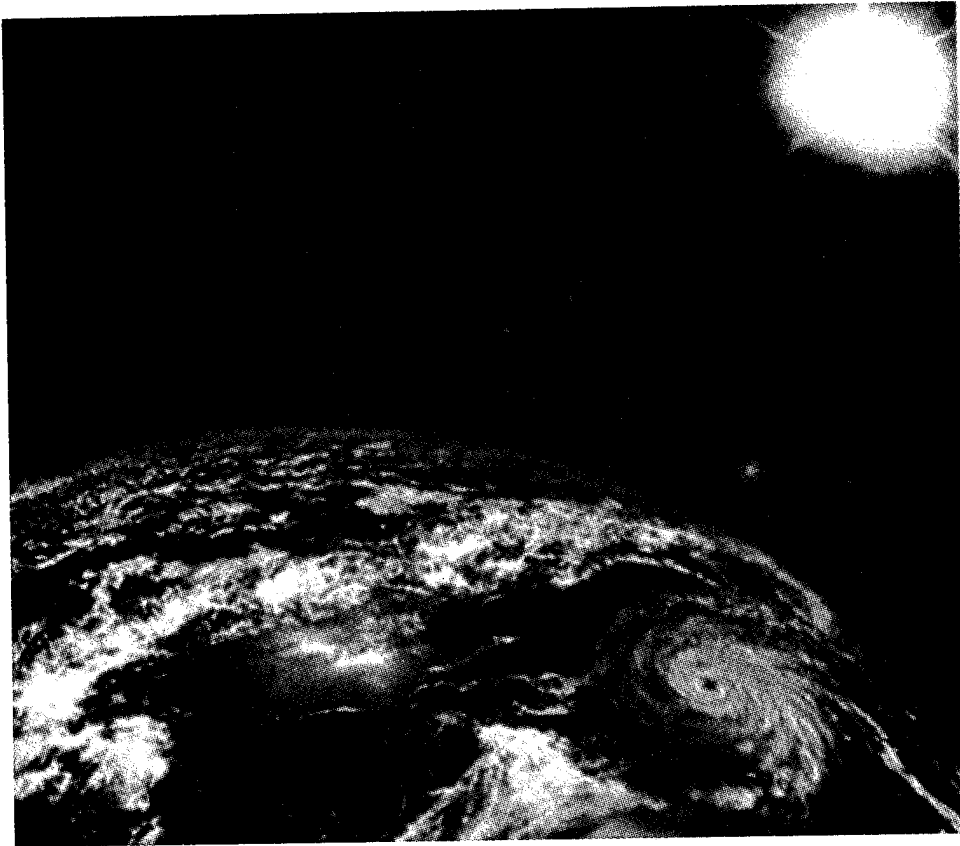
## **II. Open-ended or Constructed - Response Items**

Answer the following.

1. There are some chemical changes in water that bring harmful effects to humans and properties. Name some of these changes and explain why you consider them harmful.
2. Give two materials from each of the sources below that make water unfit for human use: (a) homes, (b) markets, (c) hospitals, (d) factories, and (e) farms. Explain their effects on you.

## Unit VIII

### Changes in the Atmosphere



Thus far, we have studied three of the four Earth's components that interact with each other—the living components, the lithosphere, and the hydrosphere. Now we are going to study the fourth component, the atmosphere. How do we interact with the atmosphere? At some time during the year, before you go out, you ask yourself what the weather would be like for the day. You are interested to know the weather so that you will be guided as to what activities to do, what clothes to wear, or whether or not it is necessary for you to bring an umbrella. You are affected by weather, an atmospheric phenomenon.

Look at the smoke that comes from factories and vehicles. Where do they end up? How far do these pollutants disperse in the atmosphere? Is the atmosphere a limitless space we dump our pollutants to?

## Lesson 8.1 The Layers of the Atmosphere

How far outward does the atmosphere extend? What are its components? About 99% of the gases that make up our atmosphere lie within 30 km from Earth's surface. This is very small in comparison to Earth's 6,400-km radius. Yet, this very thin layer of gases enables life on Earth to exist. Human activities are actually concentrated in a much thinner blanket of the atmosphere. And did you know that within this very limited space, we also dump most of air pollutants?

Table 8.1 shows the percentage by volume of the gases that make up the atmosphere. Which gas is the most abundant in the atmosphere? How much more abundant is nitrogen than oxygen in the air?

Suppose the percentage of nitrogen and oxygen in air were reversed, what do you think would happen? Oxidation will proceed at a much faster rate—we will age sooner, fruits will ripen faster, rusting and burning will go on at a much faster rate.

What if the concentration of carbon dioxide and nitrogen were reversed? Would life exist on Earth? The 0.03% concentration of carbon dioxide is sufficient to keep Earth warm and permits life to exist. Increasing its concentration to 78% will greatly increase Earth's temperature.

Do you now see that even the gas composition of the atmosphere is made just right for us? Altering it will surely result in imbalance. What do you think are some human activities that tend to change the concentration of the gases in the atmosphere?

**Table 8.1 Average Composition of Dry Air**

Substance	Percentage by Volume
Nitrogen	78.03
Oxygen	20.99
Argon	0.94
Carbon Dioxide	0.03
Hydrogen	0.01
Neon	0.00123
Helium	0.0004
Krypton	0.00005
Xenon	0.00006
Radon	trace

### Air Pressure

If you were in an airplane that is taking off, or in a bus going uphill, what sensation do you feel in your eardrum? Why do you think that is so?

The molecules of air in our atmosphere are not uniformly distributed. The air gets progressively thinner as altitude increases. In fact, more than half of all the air molecules in the atmosphere are within 5.5 km of Earth's surface. This is because Earth's gravity pulls down the molecules in the atmosphere. The weight of the upper atmosphere presses down or compresses the lower portion.



How great is the pressure exerted by the atmosphere? Recall your activity related to Figures 4.9 and 4.10.

An Italian mathematician by the name of Evangelista Torricelli (1608–1647) made a precise measurement of atmospheric pressure using his invention known as mercury barometer. He found out that the atmospheric pressure at sea level is  $101\,325\text{ N/m}^2$ . This is due to the weight of all the overlying air. There is less and less air as altitude increases. Pressure at higher levels is therefore lower than at sea level.

Weathermen, or meteorologists, use another unit of measurement for recording atmospheric pressure. It is called hectoPascal (hPa).

$$\begin{aligned} 1\text{ atm} &= 1\,013.25\text{ hPa} \\ &= 101\,325\text{ N/m}^2 \end{aligned}$$

The pressure exerted by a gas depends on two competing factors: density and temperature. An increase in density tends to increase pressure while an increase in temperature tends to decrease pressure. How does temperature vary in the atmosphere?

## Air Temperature

Temperature changes so much with altitude that one can identify major divisions or layers of the atmosphere based on temperature variations as shown in Figure 8.1.

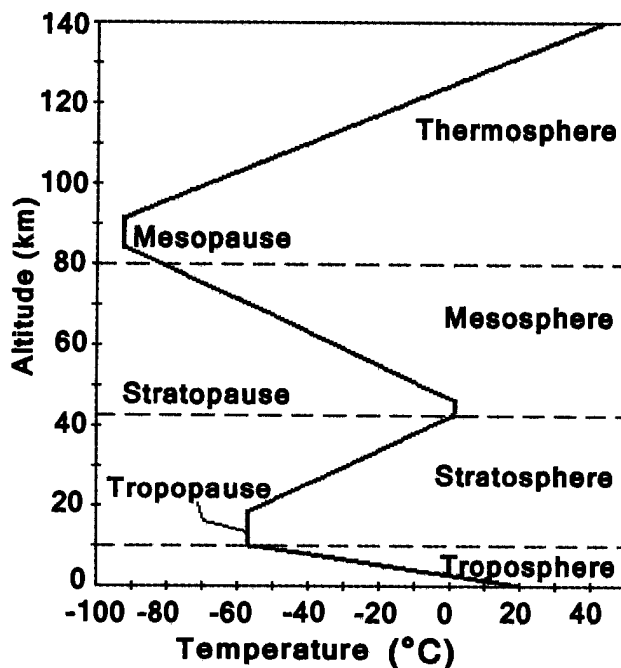


Figure 8.1 Temperature profile of the atmosphere

## Activity 8.1 Temperature Profile of the Atmosphere

### Procedure

1. Study Figure 8.1, a graph of change of air temperature with altitude. Note the different layers of the atmosphere and their temperature variations.
  - a. In what layers of the atmosphere does temperature increase with height? Decrease as height increases?
  - b. In the troposphere, why does temperature decrease as altitude increases?
  - c. Why does the temperature in the stratosphere increase with height?
  - d. In the mesosphere, temperature decreases as height increases. What do you think causes this temperature variation?
  - e. Temperature increases with altitude in the thermosphere. Give a possible explanation.

The temperature profile of the average atmosphere is the basis of dividing the atmosphere into four layers: the troposphere, stratosphere, mesosphere, and thermosphere. This temperature profile shown in Figure 8.1 is an average of temperature profiles obtained from all over the globe, over a long period of time. At any particular place and time, the profile can look quite different.

The **troposphere** is where most of the air (over 80% of the total mass of the atmosphere) is found. It extends up to an altitude of 16 to 18 km above sea level at the equator, and around 8 km at the poles. The air becomes colder as the distance from the ground increases. The average rate of temperature decrease is about 6.5 °C per km of altitude increase (or ascent). Why is this so?

Why is the upper part of the troposphere cooler than its lower portion when it is nearer the sun than the lower atmosphere? The troposphere is not directly warmed by sunlight. Most of the visible light incident on Earth pass through the atmosphere and reach Earth's surface, causing Earth's surface to become warm and emit infrared radiation.

Gases in the air such as carbon dioxide and water vapor absorb infrared radiation. Absorption of infrared radiation from the surface warms the lower atmosphere. Thus, the troposphere is not warmed from above but from below. Earth's surface serves as the heat source for the troposphere. Increasing distance from the surface, therefore, results in decreasing temperature since this means moving away from the heat source. This results in a decreasing temperature profile as altitude increases in the troposphere.

Note that at the top of each layer there is a “pause” where the temperature changes abruptly. At the top of the troposphere is the **tropopause**, a region where the temperature stops decreasing. The tropopause is highest in the tropical areas and lowest near the poles.

In contrast to the troposphere, temperatures in the **stratosphere** rise with increasing altitude. What could be the reason for such a temperature profile? The ozone layer, found at the stratosphere highly absorbs ultraviolet (UV) radiation from the sun. Absorption of UV warms the surrounding air, leading to an increase of temperature. UV absorption is greatest at the uppermost level of the stratosphere; hence air temperature is also highest in this region. Absorption of UV at higher levels lowers the amount that is available at lower levels of the atmosphere.

The “pause” at the top of the stratosphere is the **stratopause**. Above the stratopause is the mesosphere. With no gas that absorbs sunlight in this layer, the temperature decreases with height up to the **mesopause**.

In the uppermost layer (above 90 km), we find the **thermosphere**. In this layer, temperature increases with altitude due to the absorption of high-energy radiation from the sun. This fourth major division extends to the outer limits of the atmosphere around 1 000 km above the ground.

Q8.1 It is cooler in Baguio than in Manila. Baguio is at a higher altitude than Manila. Shouldn't it be warmer in Baguio since it is a lot closer to the sun?

## Lesson 8.2 Weather Elements

Weather phenomena such as clouds, rain, and typhoons are limited to the lowest layer of our atmosphere—the troposphere. Hence, this is also known as the weather layer. When we talk about weather, we consider weather elements. What are the different weather elements? How does one element affect the other elements?

### Temperature

Temperature is one of the weather elements that has a direct effect on humans. Adjustments in lifestyle and activities have to be made according to the predicted temperature range for the day.

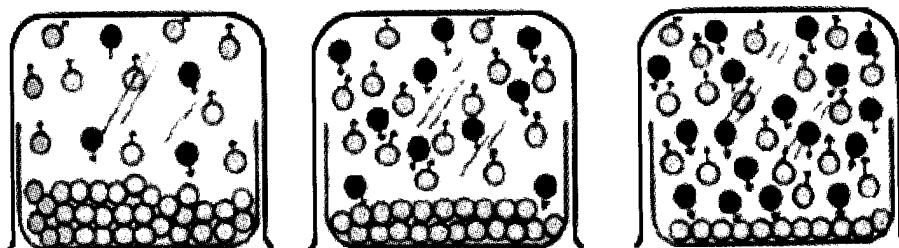
You learned that air temperature varies with altitude. Horizontally, there can also be great variations in air temperature. These variations can be due to the nature of the surface and the rate at which energy is

absorbed or emitted. Changes in air temperature can also affect other weather elements such as pressure and humidity.

## Humidity

Have you noticed that sometimes, we feel very uncomfortable even when the air temperature is not that high? During these times, the air is said to be humid.

The amount of water vapor in the air is referred to as **humidity**. Some textbooks contain such phrases as air holds water vapor or that air has a water vapor holding capacity like a sponge. It must be emphasized, however, that air does not literally “hold” the water vapor. Air is a mixture of gases with molecules that are always in random motion. Water vapor is also a gas with molecules that are always in random motion. From this perspective, it is easy to see that the constantly moving molecules in air cannot possibly “hold” the constantly moving molecules in water vapor. Air does not even have to be there for water vapor to exist.



(a) Actual amount of water that evaporates is high because the number of water molecules that evaporate is greater than those that condense.

(b) As more water vapor molecules crowd the air above, more water vapor molecules fall back to the liquid water. Evaporation is slow.

(c) The number of water molecules escaping into the air equals the number returning to the dish. Net evaporation is zero.

*Figure 8.2 Water vapor content of air is dependent on evaporation and condensation rates.*

Figure 8.2 shows that evaporation and condensation of water is continuously taking place. The actual amount of water vapor in the air depends on which of these two processes dominates. Figure 8.2a shows that there is a net evaporation of water since the evaporation rate is greater than the condensation rate. Figure 8.2b shows that there is a net condensation of water since the condensation rate is greater than the evaporation rate. When condensation and evaporation rates are equal

(Figure 8.2c), the amount of water vapor in the air remains constant. Does this mean that evaporation has stopped?

This simply means that the amount of water vapor that is added to air through evaporation is equal to the amount that is removed through condensation.

### Measuring the Water Vapor Content of Air

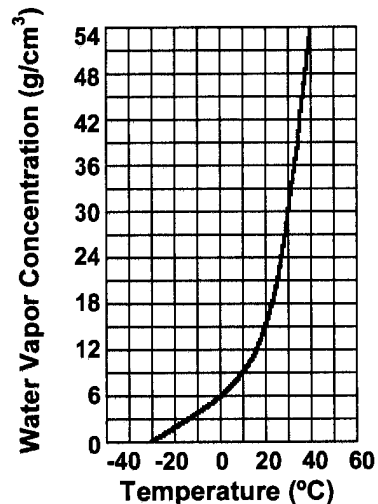
One of the most important measures of the water vapor content of air is relative humidity (RH). This is the ratio of the actual amount of water vapor in a sample of air compared to the maximum amount of water vapor that can be in the air at a given temperature and pressure.

At a given temperature, there is a limit to the amount of water vapor in the air. When this limit is reached, the air is said to be saturated.

#### Activity 8.2 Amount of Water Vapor at Saturation

##### Procedure

1. Study the graph at the right.
  - a. What does the graph show?
  - b. Air at 0 °C is very cold. Is there water vapor in the air at this temperature?
  - c. At what temperature does the vapor content in air originally at 20 °C double?
  - d. How does the water vapor content of air change with increasing temperature?



$$RH(\%) = \frac{\text{actual amount of water vapor}}{\text{amount of water vapor at saturation}} \times 100$$

From Activity 8.2, we can see that the water vapor content of air at saturation increases with temperature. Warm saturated air contains more water vapor than cooler saturated air.

Since the water vapor content of air at saturation changes with temperature, so does the relative humidity (RH). RH only indicates the degree of saturation of air. It is not an indication of the actual amount of water vapor.

You will use the RH charts shown in Figure 8.3 for Activity 8.3.

Dry Bulb (°C)	Wet Bulb Temperature (°C)														
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
10	100														
11	88	100													
12	78	89	100												
13	68	79	89	100											
14	60	69	79	89	100										
15	52	61	70	80	90	100									
16	45	54	62	71	81	90	100								
17	39	47	55	63	72	81	90	100							
18	33	41	48	56	64	73	82	90	100						
19	28	35	42	50	57	65	73	82	91	100					
20		30	37	44	51	58	66	74	82	91	100				
21		26	32	38	45	52	59	67	75	83	91	100			
22			27	34	40	46	53	60	68	75	83	91	100		
23			23	29	35	41	48	54	61	68	76	84	92	100	
24				25	31	37	43	49	55	62	69	76	84	92	100
25				22	27	32	36	44	50	56	63	70	77	84	93
26				18	23	28	34	39	45	51	57	64	70	77	85
27					20	25	30	35	41	48	52	58	64	71	78
28					17	22	26	31	36	42	47	53	49	65	72
29						19	23	28	33	38	43	48	45	60	66
30						16	20	25	29	34	39	44	41	55	61
31						14	18	22	26	31	35	40	38	50	56
32							15	19	23	28	32	36	34	46	51
33							13	17	21	25	29	33	31	42	47
34								15	18	22	26	30	28	39	43
35									16	20	23	17	26	35	40
36										17	21	24	23	32	36
37											19	22	21	29	33
38												20		27	30
39														24	28
40															22

Dry Bulb (°C)	Wet Bulb Temperature (°C)														
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
25	100														
26	92	100													
27	85	92	100												
28	78	85	92	100											
29	72	79	86	93	100										
30	66	73	79	86	93	100									
31	61	67	73	80	83	93	100								
32	56	62	68	74	80	86	93	100							
33	52	57	63	68	74	80	83	93	100						
34	48	53	58	63	69	74	80	87	93	100					
35	40	49	54	59	64	69	75	81	87	93	100				
36	37	45	50	54	59	64	70	75	81	87	93	100			
37	34	41	46	50	55	60	65	70	76	81	87	94	100		
38	32	38	42	46	51	56	60	65	71	76	82	88	94	100	
39	29	35	39	43		52		61		71	76	82	88	94	100
40		32	36								71	77	82	88	94
41												72		82	
42												67			
43												63			

Figure 8.3 Relative Humidity Chart

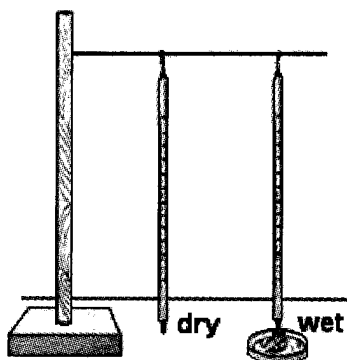
### Activity 8.3 Relative Humidity

#### Materials

- |                                       |                        |
|---------------------------------------|------------------------|
| 2 identical thermometers (0 to 50 °C) | gauze                  |
| Relative Humidity Chart               | distilled or tap water |
| small water container                 | iron stand             |

#### Procedure

- Wet the gauze cloth with distilled water.
- Fill the small water container and immerse the gauze cloth. This will keep the gauze moist.
- Suspend both thermometers from an iron stand.
- Fan both thermometers lightly and note any changes in temperature.
- Continue fanning until the temperature stops changing. Record the readings on the dry- and wet-bulb thermometers.
  - What does the dry bulb reading represent?



On the RH chart, two thermometer readings are shown. The top row contains the readings of the wet bulb. The leftmost column contains readings of the dry bulb. The value given at the intersection of the dry and wet bulb readings is the RH value in percent.

Set aside your setup. Take two more readings two hours apart.

Time	Air Temperature		RH
	Wet Bulb	Dry Bulb	

- Compare the wet and dry bulb readings?
- Is it possible for the wet and dry bulb readings to be equal? What is the RH at this point? Check your chart.
- Relative humidity affects the rate at which liquid water evaporates. A lower RH usually favors evaporation while high RH hinders evaporation.

- e. When will you feel more comfortable, during periods of high or low RH? Why?
- f. Assuming that the actual amount of water vapor remains constant, how will an increase or a decrease in temperature affect RH?
- g. The RH taken on two different days was measured to be 76% at around 12 noon. Is it correct to assume that the amount of water vapor in the air for both days is equal? Give numerical examples to explain your answer.

Let us consider the RH on two different days. On day 1, air temperature is 30 °C and RH is 75%. The RH is also 75% on day 2 but air temperature is only 20 °C. Is the water vapor content of air equal on both days?

Clearly, the air in both days is 75% saturated. You can see from the graph that the water vapor content of air (day 1) at 30 °C is 30 g/m<sup>3</sup>. Since the air is only 75% saturated, actual water vapor content is 75% of this amount (22.5 g/m<sup>3</sup>). At 20 °C (day 2), saturated air contains about 17 g/m<sup>3</sup>. For 75% RH, the actual water content is only 12.75 g/m<sup>3</sup>. Although the RH is the same on both days, the actual water vapor content differ.

Q8.2 Assuming that the water vapor content of air is constant, how is RH affected by a decrease in temperature?

To measure RH, there is no need to measure the actual water vapor content of air. An easier way is to use an instrument known as a **hygrometer** (Activity 8.3). Basically, it is composed of a pair of thermometers with one having its bulb wrapped in wet gauze. The difference in temperatures of both thermometers is an indication of the RH.

For weather prediction, RH is a more useful measure than the actual water vapor content of air. This is because the condensation of water vapor is based on the RH and not on the actual water vapor content. Condensation starts when RH reaches 100%. But in reality, condensation begins even at RH values below 100% because of the presence of so-called condensation nuclei such as dust and smoke particles. They provide surfaces on which tiny water droplets can adhere to and aggregate to form large water drops.

## Atmospheric Pressure

Measurements of atmospheric pressure are very important for weather prediction. In weather reports, you often hear of terms such as



low-pressure area, or ridge of high pressure. Do you know how atmospheric pressure affects weather?

Atmospheric pressure is measured with a device known as a **barometer**. In its simplest form, it consists of a long glass tube open at one end that is filled with mercury. This is then inverted in a reservoir that is also filled with mercury.

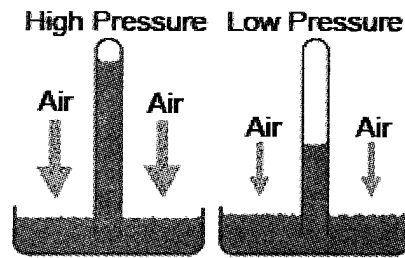


Figure 8.4 A simple mercury barometer

Although the tube is open at one end, atmospheric pressure prevents the mercury from completely running out of the tube. The height of the mercury column thus provides a measure of atmospheric pressure, rising and falling with changes in atmospheric pressure. Rising air pressure causes a greater push on the liquid in the reservoir leading to an increase in the level of mercury in the glass tube.

The traditional unit for pressure measurements is the millibar (mb). The current SI unit is the hectoPascal (hPa). This unit is numerically equivalent to the millibar. Hence, one hectoPascal equals one millibar.

The standard atmospheric pressure at sea level is about 1 013.25 hPa. This corresponds to a force of 101 325 N/m<sup>2</sup>.

Air pressure is due to the collision of gas molecules with surfaces. Because air is compressible, air at lower altitudes is denser and more compressed than air at higher altitudes. Thus, the atmosphere rapidly thins out with increasing altitude (Figure 8.5).

Although air pressure varies greatly with altitude, it is the horizontal variations in pressure that is more important. A low-pressure area is characterized by rising air and cloudiness. Figure 8.5 shows the wind flow around a low-pressure area. In the northern hemisphere, the wind spirals inward in a counterclockwise manner. The deflection of winds is due to the Coriolis force.

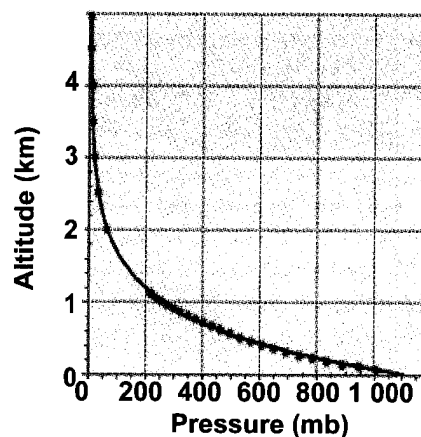
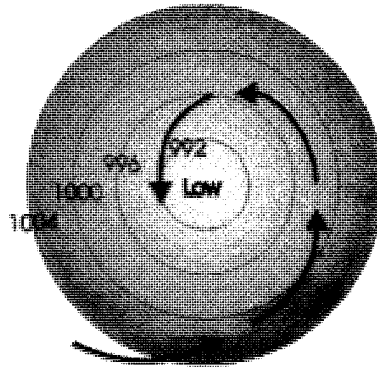


Figure 8.5 Change of air pressure with altitude

Low-pressure systems like typhoons are characterized by upward motion of air which can lead to cloud formation and rainfall. This is why low-pressure systems usually bring bad weather.

For a high-pressure system, the wind spirals outward in a clockwise manner. The sinking air in high-pressure systems is warm and relatively free of clouds. Thus, high-pressure systems are associated with clear skies and good weather.



*Figure 8.6 Wind flow around a low-pressure area*

## Wind

Unequal heating of Earth's surface results in differences in temperature. Warm air in the heated areas expands and rises leading to a lowering of pressure at the surface. The pressure difference leads to the movement of air at the surface, which we refer to as **wind**. Generally, wind flows from an area of high pressure to an area of lower pressure.

Two important measurements of wind are the direction and speed. Wind speed is generally recorded in kilometres per hour (kph) or in metres per second (m/s).

Wind direction is not given in relation to the direction in which it is blowing, but rather the direction from which the wind is coming from. Thus, a northeasterly wind comes from the northeast while a southwesterly wind blows from the southwest.

The simplest way to measure the wind direction and speed at Earth's surface is with wind cups and vanes. The vane gives the direction while the cup catches the wind and rotates giving an indication of speed. Wind speeds and directions at the surface and aloft help us to predict where and how fast weather systems will move.

## Lesson 8.3 Weather Phenomena

We will now discuss some weather phenomena to see how the different weather elements are interrelated.

## Clouds

Clouds provide an indication of the dynamic nature of our atmosphere. You learned about the different cloud types in your elementary grades. Regardless of its type, a cloud is just a collection of very fine condensed water or sometimes ice particles. Do you know how clouds form? Consider an imaginary parcel of air near the ground that is surrounded by a very thin flexible cover so that no air can get in or out of the parcel. As sunlight warms the ground, the air parcel warms and becomes less dense. Hence, it becomes buoyant and it rises. What happens to air as it rises?

Recall that air pressure decreases with altitude. The low pressure causes the rising parcel of air to expand. The expansion, in turn, results in cooling of the rising air. On the average a rising parcel of air cools by about  $6.5\text{ C}^\circ$  per kilometre that it rises. What happens to the RH as air cools?

Assuming that the original water vapor content of the air parcel does not change, the RH will increase as the air parcel rises and cools. At a certain level, the water in the air parcel will begin to condense and a cloud will be formed.

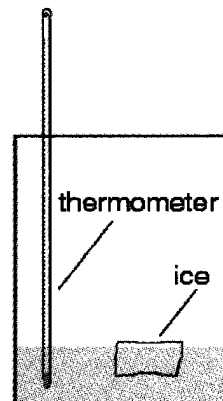
### Activity 8.4 Estimating Cloud Height

#### Materials

shiny metal cup      ice cubes  
thermometer        stirring rod

#### Procedure

1. Measure the air temperature. Do not hold the thermometer close to any heat source such as your body or a lamp while doing this.
2. Pour about 2.5 cm of tap water into the metal cup. Wipe the outside of the cup and make sure that it is completely dry.
3. Keep the thermometer immersed in the water throughout the experiment. It should not touch any side of the container.
4. Drop an ice cube into the water and stir constantly with a stirring rod.
5. Another group member should watch the outer side of the cup for any mist or condensation.



6. Record the water temperature when the first sign of mist appears on the outer surface of the metal cup.
7. Remove any remaining ice in the cup and continue stirring the water. Wait for the water in the cup to warm until the mist disappears.
8. Record the water temperature when the mist completely evaporates from the metal surface.
9. The dew point is the average of your two temperature readings.
  - a. How does the dew point change if the amount of water vapor in the air changes?
  - b. On a Monday, the air temperature is measured at noontime to be 30°C and the dew point is 25°C. At about the same time the next day the air temperature is also 30°C but the dew point is 20°C. In which day is there more water vapor in the air? Explain.
  - c. How is the RH related to the difference between the air temperature and the dew point?
  - d. What is the RH of a parcel of air that is cooled to its dew point?
10. The estimation of the height at which clouds will form is based on the assumption that a rising parcel of dry air will cool at a steady rate. Having measured the dew point, the height can be computed as:

$$\text{Height (in metres)} = 125 \times (T - T_d)$$

$T$  = air temperature,  $T_d$  = dew point

If you look at the sky on a warm sunny day, you will notice that the clouds form only beyond a certain height. The activity you just performed will help you estimate at what height clouds begin to form. Normally, clouds form within 1 km from the ground. This height has very important implications on the transport of air pollutants.

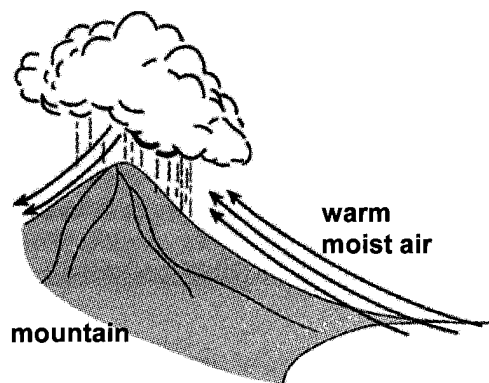


Figure 8.7 Clouds formed by forced ascent of air

Clouds can also be formed by the forced ascent of air. Figure 8.7 shows that the

presence of a mountain deflects the wind upward resulting in expansion and cooling of the rising air. Condensation usually starts near the top of the mountain when the air has cooled sufficiently. The side of the mountain that is exposed to the wind (windward side) tends to have more rainfall than the other side (leeward side). The air that goes down on the leeward side is compressed and warmed as it descends. The leeward side tends to be drier since clouds and precipitation are less likely to form on this side.

## Typhoons

Typhoons are massive weather phenomena unique to the tropics. Generally, these are known as **tropical cyclones**.

Tropical cyclones are weather disturbances characterized by a low-pressure center, high-speed winds, and rain. Although the winds in a tropical cyclone are generally strong, the center is usually calm and warmer than the surrounding air.

Depending on the wind speed near the center, a tropical cyclone can be classified as tropical depression (60 kph or less), tropical storm (from 60 to 118 kph), or a typhoon (greater than 118 kph). Other countries have different names for tropical cyclones but their structure and mechanism of formation are similar.

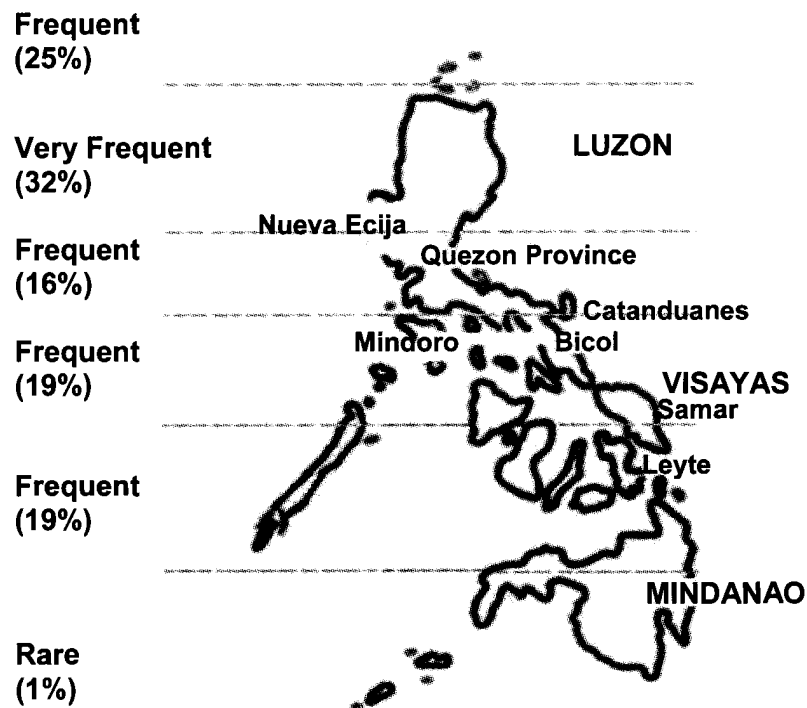


Figure 8.8 Frequency of tropical cyclone occurrences in the Philippines

On the average, our country experiences about 20 tropical cyclones per year. The frequency of tropical cyclone occurrences for different parts of the Philippines is shown in Figure 8.8. Which location experiences the most number of tropical cyclones? the least?

Note that Northern Luzon has the highest frequency of tropical cyclone occurrences while Mindanao has the lowest frequency. What could be the reason for this?

The Philippines is located near a very productive breeding ground for tropical cyclones (Figure 8.9): the Pacific Ocean. It is not surprising that we experience many tropical cyclones.

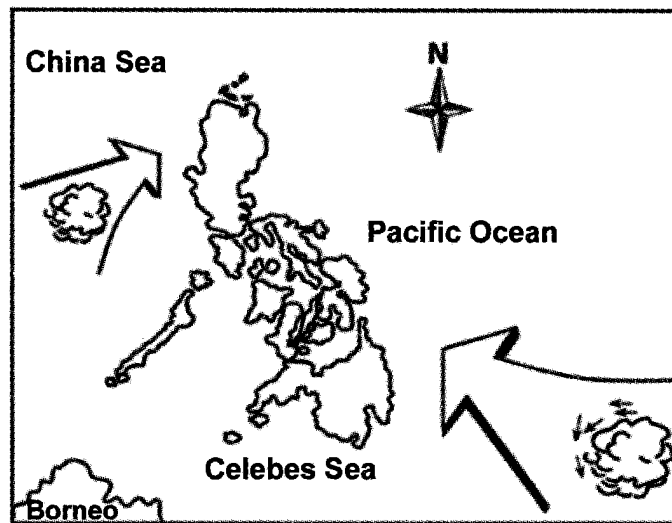
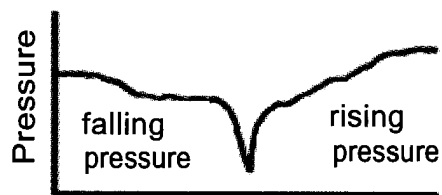


Figure 8.9 Origin of Philippine tropical cyclones

Figure 8.10 shows the structure of a typhoon and the associated pressure measurements. The lowest pressure is found within the eye, increasing rapidly outward.



The clouds associated with a typhoon form even at great distances from the eye. Cloud formation and rainfall is greatest around the eye. But surprisingly, the eye is usually free of clouds with little or no winds.

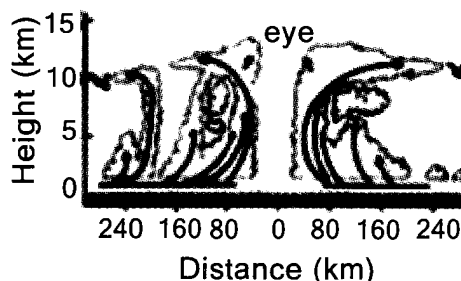


Figure 8.10 Structure of a typhoon

Around the eye, there is a very rapid upward movement

of air leading to cloud formation and rain. Within the eye, the air undergoes a sinking motion. Increasing pressure at the lower levels compresses the air that results in an increase in temperature. Thus, the warm air within the eye remains relatively free of clouds.

A typhoon usually forms over warm tropical oceans that are sufficiently far from the equator (greater than  $5^\circ$ ). Condensation of water vapor releases vast amounts of energy to the surrounding air. Warming of the air makes it more buoyant and causes it to rise even more. The reduction of pressure causes air at the surface to rush toward the center and rise, releasing even more energy as the water vapor condenses. Depending on certain conditions, this process can go on and on and can intensify to a tropical cyclone.

Condensation of water vapor serves as the fuel that keeps the typhoon going. When a typhoon makes landfall, its energy source is cut off and it starts to dissipate within a few days.

## Lesson 8.4 Seasons

The length of days and nights vary. There are times when the days are longer and the nights shorter while there are periods during the year when the nights become longer and the days shorter. Why is this so?

Earth revolves around the sun while it is rotating on its axis. When viewed from the North Pole, the rotation and revolution of the Earth is counterclockwise. But when viewed from the South Pole, these motions are clockwise.

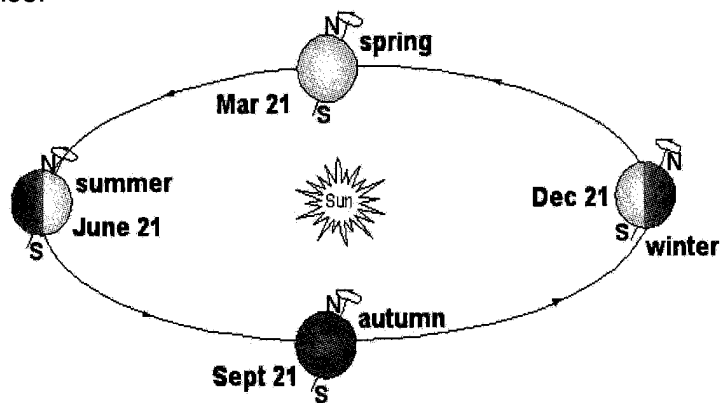


Figure 8.11 Earth and its orbit at different times of the year

Earth's axis is an imaginary line that runs through its North and South poles. Note that the tilt of Earth, which is about 23.5 degrees from the plane of its orbit, remains at the same angle and direction as it revolves around the sun (Figure 8.11). Scientists infer this from the fact that the North Pole of the planet Earth always tilts or points toward the North Star

or Polaris. One complete rotation on its axis takes approximately 24 hours. This rotation explains why most (but not all) people on Earth experience day and night hours regularly every 24 hours.

At any given time, half of the Earth is illuminated by sunlight and half is in darkness. Due to Earth's tilt, the amount of illumination for each hemisphere varies. Figure 8.12 shows that the southern hemisphere is more illuminated.

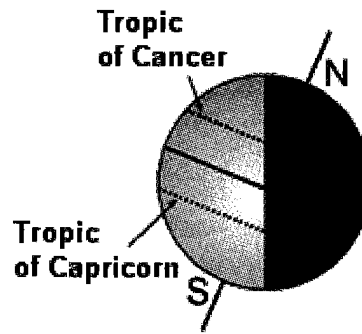


Figure 8.12 Illuminated areas for each hemisphere

Q8.3 Based on Figure 8.11 say Yes if you agree to the statement and No if you disagree.

- On June 21, the North Pole experiences 24 hours of daylight.
- At the equator, the duration of daytime and nighttime is about the same.
- On December 21, the North Pole experiences 24 hours of nighttime. The South Pole experiences 24 hours of daytime.

If you answered yes to all the statements, then you have interpreted the figure correctly.

The rays of sunlight can be assumed to be parallel as they reach Earth because of its great distance from the sun.

Around December 21 (the winter solstice in the Northern hemisphere), the sun's rays shine perpendicularly at  $23.5^{\circ}$  S (Tropic of Capricorn) at noontime. During this time, the southern hemisphere is exposed to more sunlight than the northern hemisphere. Consequently, daytime is generally longer in the southern hemisphere while nighttime is longer for most of the northern hemisphere. People near the North Pole experience 24 hours of nighttime while those in the South Pole experience 24 hours of daytime.

After three months, Earth would have traversed one quarter of its orbit and the sun's rays strike perpendicularly at the equator. This is the vernal (spring) equinox which happens around March 21. All throughout the world, nighttime and daytime have the same duration.

After another three months, around June 21, Earth is already halfway in its orbit. The sun's rays strike perpendicularly at  $23.5^{\circ}$  N (Tropic of Cancer). The northern hemisphere experiences summer and daytime is generally longer than nighttime.



Earth traverses one more quarter of its orbit in another three months. Around September 21, the sun's rays strike perpendicularly at the equator (autumnal equinox). After three more months, Earth will have completed its orbit.

Q8.4 In the southern hemisphere, what happens to the lengths of days for the period June 21 to December 22? from December 22 to June 21?

In temperate regions, there are four seasons that can be observed in a year:

Season	Period	
	Northern Hemisphere	Southern Hemisphere
Summer	June 21 to September 22	December 21 to March 22
Autumn	September 22 to December 21	March 22 to June 21
Winter	December 21 to March 21	June 21 to September 22
Spring	March 21 to June 21	September 22 to December 21

## Seasons in the Philippines

Areas near the equator or the tropics (like that of the Philippines) do not have four seasons. Tropical countries generally experience two seasons: wet and dry.

Air temperature in our country does vary much (only about 5 to 6 C°), but we do feel hotter from late March to May, our so-called **summer** months. The cold months are from November to February. What explains this?

The sun's rays shine more directly on Earth at noon than at other times of the day. Due to Earth's round surface, the sun's noon rays strike the equator most directly on March 21 and September 22, while all other areas receive slanting rays. After March 21, the sun's noon rays shine directly at higher and higher latitudes every day, even as the Earth rotates, until on June 21 when they are perpendicular at 23.5° N latitude. Due to Earth's rotation, sun's noon rays shift southward reaching the equator on September 22. The rays continue shifting southward until December 22, when they directly strike Earth at 23.5° S latitude.

This means that in the Philippines, the sun's most direct noon rays sweep northward (5° N to 21° N latitude) from April 4 to May 26; then sweep southward from July 19 to about August 14. The northward sweep explains why it is hot in the Philippines during the later part of March through April and May—the months during which the hot and dry season occurs. This also explains why the country experiences hot season from July to the middle of August, if no southwest monsoon winds bring heavy rains. The southwest monsoon winds and rains provide the cooling effect

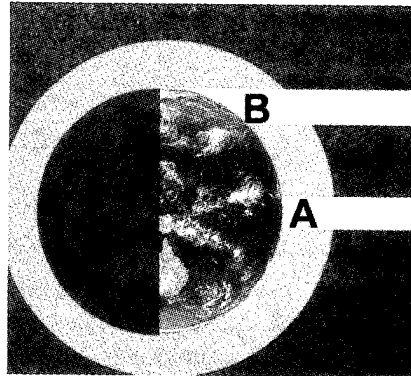
most needed during hot summer months. The remaining months of the year from November to February make up the cool and dry season.

## Lesson 8.5 General Circulation of Air

The general circulation of air is due primarily to the difference in temperature between the equatorial and polar areas. Why are tropical areas warmer than areas at higher latitudes?

Study Figure 8.13. Compare the lengths of the curved line on Earth's surface on which Rays A and B strike Earth.

Q8.5 Assuming that Earth intercepts the same amount of energy from both Rays A and B, which area would receive more energy per unit area? Which area would you expect to be warmer?



*Figure 8.13 Angle of inclination of the sun's rays in equatorial and polar areas*

Due to Earth's curvature, there is a difference in the angle that the sun's rays strike the surface. The ray near the equator strikes Earth at a nearly perpendicular angle. The ray near the poles strikes Earth at an oblique angle.

Assuming that Rays A and B have the same energy, the surface near the poles receive less energy per unit area than in tropical areas. Thus, tropical areas tend to be warmer than the polar areas. The higher the latitude of a place, the lower is the air temperature.

Take a second look at Figure 8.13. The gray circle around Earth is an exaggerated representation of the atmosphere. Which of the rays (A or B) takes a longer path through the atmosphere? How does this affect the amount of sunlight that reaches Earth's surface?

Because Ray B is at an oblique angle, it takes a longer path through the atmosphere than Ray A. Hence, there is a greater chance that some of the light will be reflected, scattered, or absorbed by air particles. This reduces the amount of energy that reaches Earth's surface in the polar areas. This further reduces the heating at the polar areas than at tropical areas.

Another factor that affects the amount of energy received in a given location is its **albedo**. The reflectivity of an object is referred to as its albedo. An object with a high albedo is highly reflective and will reflect a great percentage of the light that strikes it. Low-albedo objects reflect very little of the light that strikes them. Table 8.2 shows the albedos of some common surfaces.

**Table 8.2 Albedos of Some Common Surfaces**

Surface	Albedo
Snow	
• Old	0.40
• Fresh	0.95
Glacier	0.20 to 0.40
Soils	
• Dark, wet	0.05
• Light, dry	0.40
Desert	0.2 to 0.45
Asphalt	0.05 to 0.20
Concrete	0.10 to 0.35
Forest	
• Bare	0.15
• Leaved	0.20
Water	
Solar elevation	
• 60°	0.03
• 30°	0.06
• 10°	0.29

The polar region is mainly covered with snow. Tropical areas are covered with water or trees or asphalt and/or soil. Each of these materials reflects light in varying degrees.

- Q8.6 What can you say about the albedos of tropical and polar areas in general?
- Q8.7 How would this affect the amount of energy absorbed at the Earth's surface?

Snow and ice form in polar areas since they are cooler. The high albedo of these surfaces causes a large percentage of incident sunlight to be reflected. Less energy is therefore absorbed at the surface. In tropical areas, the exposed surfaces are mostly soil or vegetation, which have low albedos. These surfaces absorb a lot of the incident light and reflect very little. Tropical areas, therefore, tend to be warmer because the low-albedo surfaces absorb more sunlight than the high-albedo surfaces in the polar areas.

To summarize, tropical areas are warmer than the polar areas because:

- More energy is received per unit area since the sun's rays strike the surface at a nearly perpendicular angle.
- Less light is reflected or scattered since sunlight passes through less air in comparison to the polar areas.
- Low-albedo surfaces absorb more energy than the ice and snow surfaces in the polar area.

## Energy Transfer from the Equatorial to the Polar Areas

Recall the three mechanisms of heat transfer: conduction, convection, and radiation. Which of these would play a dominant role in transferring energy to the polar areas? Let us review these mechanisms briefly.

**Conduction** is the transfer of energy between objects that are in contact with each other. This means that energy cannot be transferred through conduction over large distances.

Air is not a very good conductor of heat. Only the layer of air within about one millimetre from Earth's surface is heated by conduction, transferring a small amount of energy in the process.

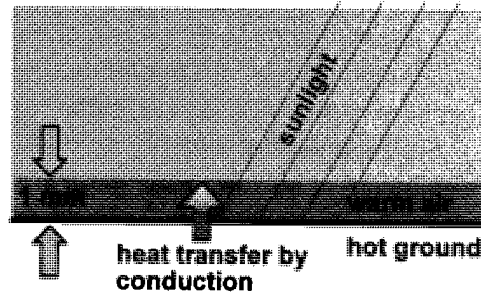


Figure 8.14 Energy transfer by conduction from Earth's surface to the atmosphere

Q8.8 Do you think water can serve as the medium for transferring significant amounts of energy through conduction, considering that over 70% of our planet is covered with water? Why or why not?

On the other hand, **radiation** transfers energy in the form of electromagnetic radiation. Unlike convection and conduction, no medium is required for energy transfer by radiation. Energy can be transferred over large distances through radiation. However, most of this transfer is in the vertical direction, away from Earth's surface. Energy cannot be transferred by radiation from one latitude to another.

We are thus left with only one mechanism: convection. **Convection** involves the movement of heated liquids or gases (collectively known as fluids). Convection is the main means by which excess energy from the equator is transferred to the polar areas. Movement of large masses of heated air gives rise to circulation from the equatorial to the polar areas.

Convection in the atmosphere accounts for only one-third of the excess energy from the equator that is transferred to the poles.

## Global Circulation

Warm air over the tropical areas rises because it is less dense. It then flows slowly toward both poles where it cools and sinks. At the surface, air flows back toward the equator, where it will again be warmed and rise.

In this situation, the equator is a low-pressure area (Figure 8.15). This flow of air toward a low-pressure area is known as **convergence**. It causes air to rise and form clouds. A low-pressure area is usually characterized by convergence and cloud formation.

On the other hand, the poles are high-pressure areas. Air sinks and flows outward at the surface. This outward flow is known as **divergence**. As opposed to rising air, sinking air warms as it goes down due to the increase in pressure. Sinking air is not conducive to cloud formation. A high-pressure area is characterized by divergence and clear skies.

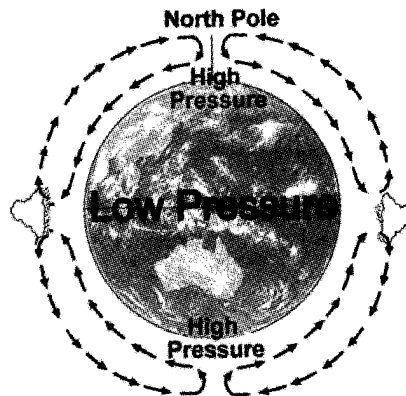


Figure 8.15 Simplified model of global air circulation

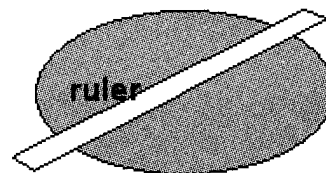
However, because of Earth's rotation, air does not simply travel from the equator to the poles. Earth's rotation results in an imaginary force, called **Coriolis force**, that greatly affects global air circulation. Global air (and water) circulation follows a curved path because of Coriolis force.

Recall that force can be described as a push or a pull. This implies that something is doing the pushing or pulling. For Coriolis force, however, there is no entity that is doing the pushing or pulling. In this sense, the Coriolis force is not a "real" force. Perform Activity 8.5 to understand what this means.

### Activity 8.5 The Coriolis Force

#### Materials

circular cardboard	ruler
pencil	push pin



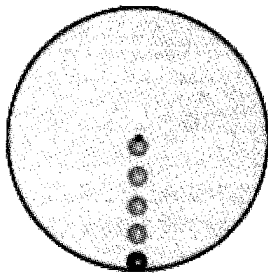
#### Procedure

1. Push the pin through the center of the cardboard and tack it to a wooden table or board. Make sure that it can rotate freely.
2. Hold the ruler over the board and have somebody slowly rotate the board.
3. While the board is being rotated, draw a straight line on the board using the ruler as a guide.

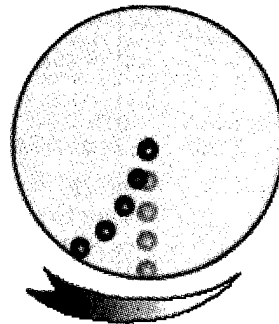
4. Make several tries and try to vary the speed of rotation for each try.
  - a. Is the line drawn on the board straight?
  - b. Does the curvature of the line change with the speed of rotation?

The key to understanding the Coriolis force is the Law of Inertia (Review Unit 4). The law states that an object will move in a straight line at the same speed if there are no unbalanced forces acting on it.

Consider a ball that is rolled from the center of a stationary circular platform as shown in Figure 8.16. By the Law of Inertia, the ball travels in a straight line at constant speed.



*Figure 8.16 Path of a ball on a nonrotating platform*



*Figure 8.17 Path of a ball as seen on a rotating platform*

How would the path change on a rotating platform? The observed path would depend on where the observer is. An observer who is not on the platform would still see a straight path, in accordance with the Law of Inertia. But to an observer who is on the rotating platform, the path would be very different.

Although the ball is actually moving in a straight line, the rotation of the platform moves the observer farther from the ball. Thus, it would appear as if the ball is following a curved path. Although, in reality there is no force causing the ball to deflect, the observer on the rotating platform would disagree. The ball accelerates (curves), hence there must be a force causing this acceleration. This is the Coriolis force.

On Earth, the motion of air (and water currents) is deflected by the Coriolis force. Furthermore, this deflection is different for each hemisphere. In the northern hemisphere, the deflection is to the right while in the southern hemisphere it is to the left. Why the difference?

In Figure 8.17, note that the deflection of the ball is to the right of its path because the platform is rotating counterclockwise. How would the

ball curve if we reverse the rotation? That's right. The ball would seem to curve to the left if the platform is rotated clockwise. How does this relate to the effect of the Coriolis force on the northern and southern hemispheres?

The perceived rotation of Earth is different for each hemisphere. When viewed from above the North Pole, Earth seems to rotate counterclockwise. Thus, air and water currents curve to the right of their paths. When viewed from the South Pole, Earth would seem to rotate clockwise. Consequently, the deflection of air and water currents would be to the left of their paths.

Let us now go back to our topic on global air circulation. The region from 0° to 5° N and S latitudes are areas of convergence. Large cloud formations are thus found in these regions. When the air has reached an altitude of about 15 km it stops rising and slowly spreads northward and southward. The air current that moves northward deflects to the right of its path because of Coriolis force. The southward air current, on the other hand, deflects to the left of its path. As the air currents reach 30 to 35° N and S latitudes, they will then move parallel to the latitudes causing the air to sink. The place where air sinks becomes a high pressure area. High pressure areas are calm.

At the surface, large scale convection currents cause winds to flow toward the equator and the poles as shown in Figure 8.18. The winds moving to the equator are called **trade winds**, because old trading ships used to depend on them for power, or **easterlies**, because they come from an easterly direction. Note that winds are named according to the direction they come from. The winds that move poleward (from 30 to 35° N),

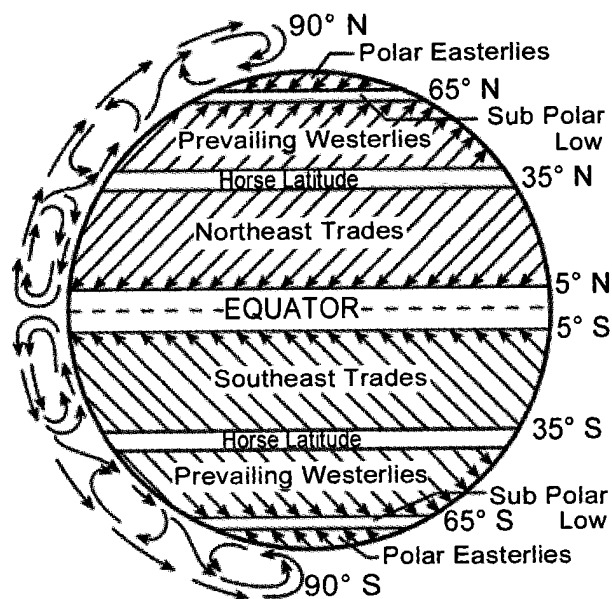


Figure 8.18 Three-cell model of air circulation

turn toward the east. They are called **prevailing westerlies** since they come from a westerly direction.

The low temperature at the poles (90° N and S) makes the air dense. Air sinks, creating a high-pressure area below. At ground level, air moves horizontally in a southwest direction from the N pole and in a northwest direction from the S pole. But, because they come from the east, the winds are called **polar easterlies**. At about 60 to 65° N and S latitudes, the polar easterlies meet the prevailing westerlies and create a belt of calm, rising air.

## Monsoons

The prevailing winds that we experience in our country are affected by our proximity to large bodies of land and water. This results in the wind systems that we refer to as **monsoons**.

The occurrence of monsoons can be explained by the difference in the heating and cooling rates of land and water. During the winter months (from December to the middle of February) in the northern hemisphere, southern Siberia and Mongolia become very cold and the area becomes a high-pressure area (Figure 8.19). Air tends to flow outward from this high-pressure area toward the low-pressure area over the north Pacific Ocean. The wind is deflected by the Coriolis force causing it to spiral clockwise. During these months, the Philippines experiences winds coming from the northeast. Thus, we have the northeast monsoon which we refer to as *hanging amihan*.

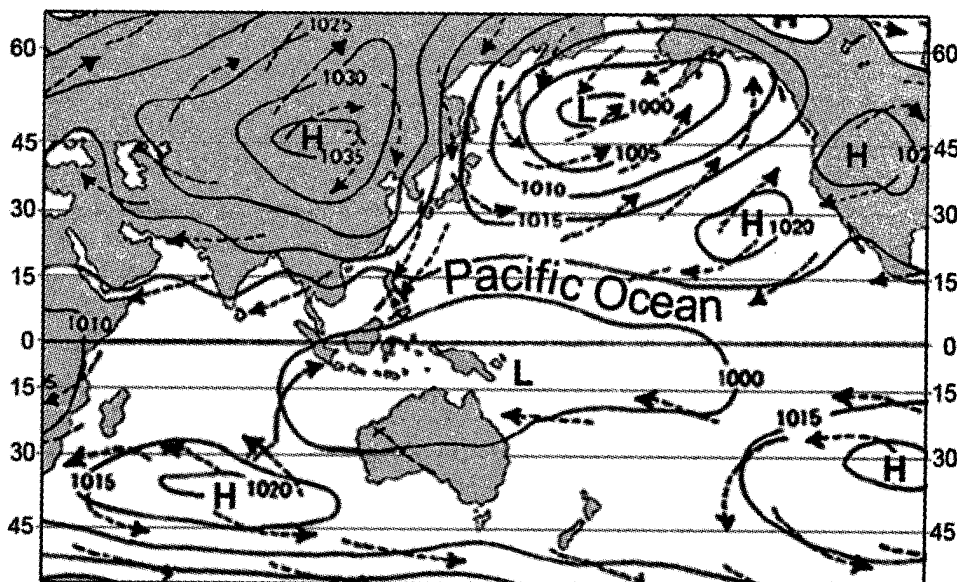


Figure 8.19 Plot of pressure and wind in January



From June to about November, low pressure (Figure 8.20) prevails over northwestern India and Pakistan. Air spirals toward a low-pressure area in a counterclockwise manner. During these months, the prevailing winds in our country come from the southwest causing the southwest monsoon which we refer to as *hanging habagat*.

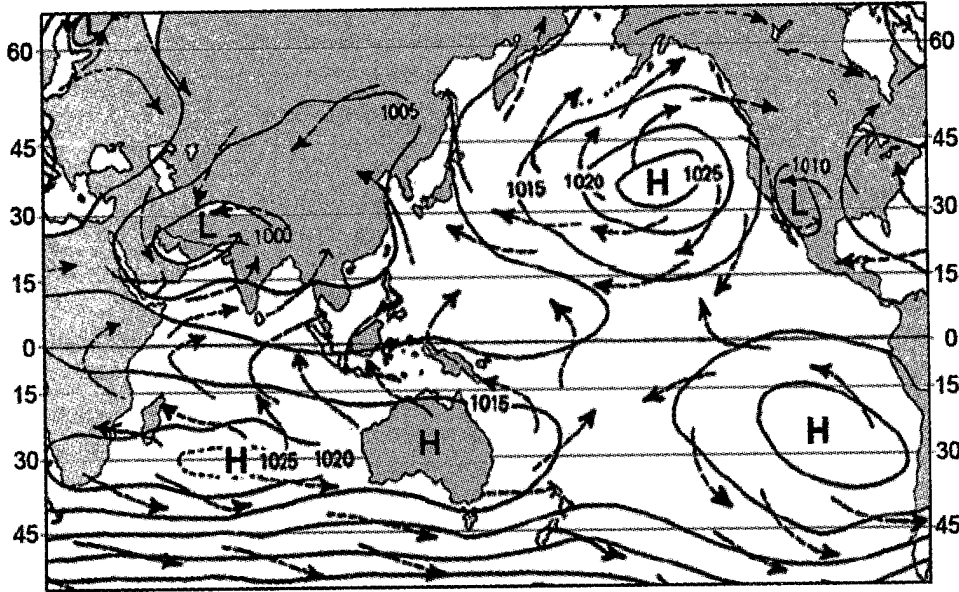


Figure 8.20 Plot of pressure and wind in July

Generally, the southeast monsoon brings more rain in comparison to the northeast monsoon. Winds of the southeast monsoon absorb moisture as they pass the warm ocean waters. This greatly increases the chances of rainfall when they reach the Philippines.

## The Intertropical Convergence Zone (ITCZ)

Sometimes you hear the term Intertropical Convergence Zone (ITCZ) in weather reports. Do you know what this is?

If you look back at Figure 8.18, you will notice that the northeast trades meet the southeast trades somewhere near the equator. This results in a band of convergence that gives rise to massive cloud formation. Where the ITCZ forms, there is an increased probability of rainfall and bad weather. Shown in Figure 8.21 is a band of clouds associated with the ITCZ. Most tropical



Figure 8.21 Cloud formation associated with the ITCZ

cyclones in the Philippines originate as weather disturbances embedded within the ITCZ.

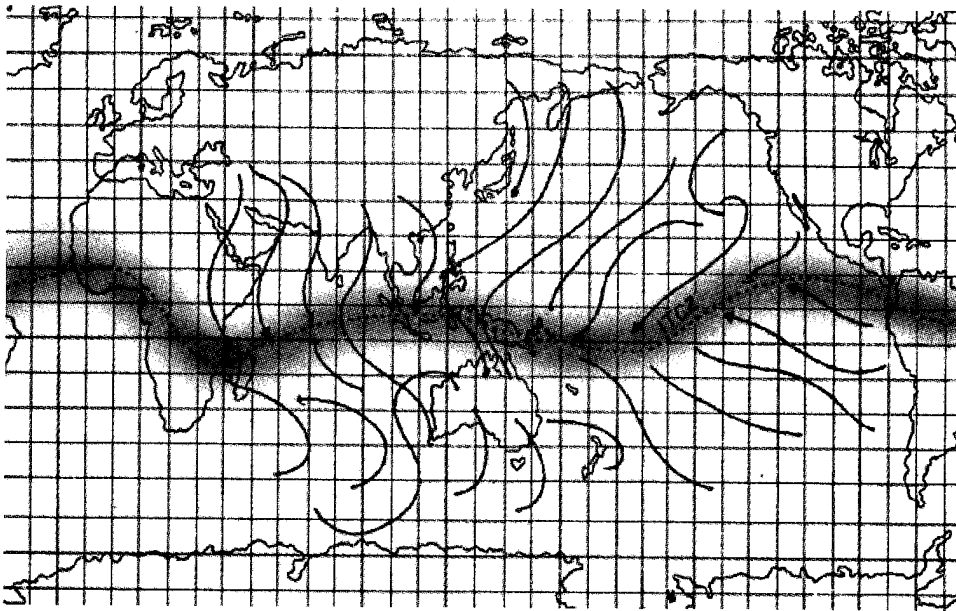


Figure 8.22 Location of the ITCZ in January (shaded curve)

The ITCZ coincides with the region of increased convective activity due to the warming of the Earth's surface. Its location varies depending on where the direct rays of the sun are. Figure 8.22 shows the approximate location of the ITCZ in January. It is wintertime in the northern hemisphere and the direct rays of the sun are south of the equator. Figure 8.23 shows a shift in the location of the ITCZ in July.

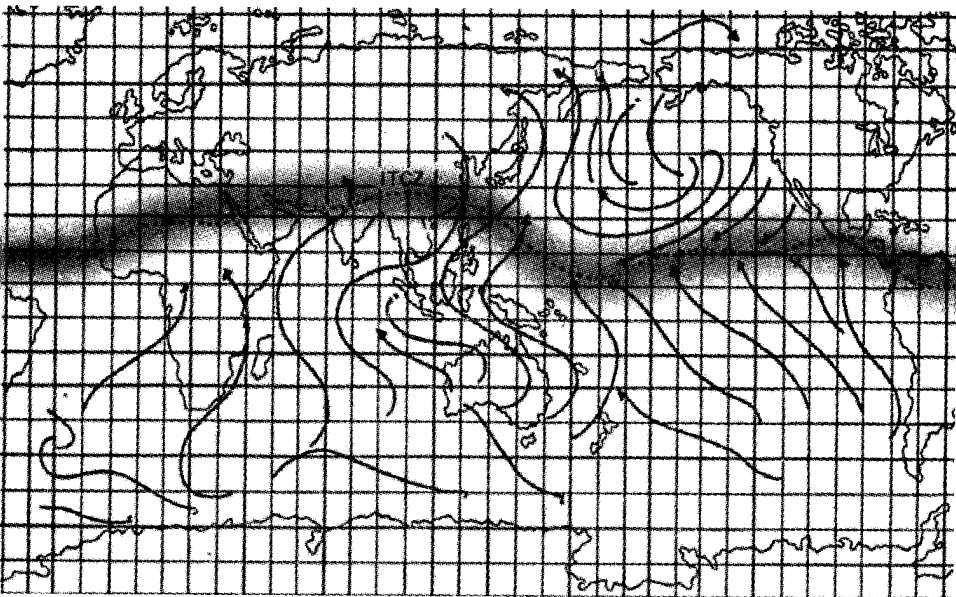


Figure 8.23 Location of the ITCZ in July (shaded curve)

During the summer months in the northern hemisphere, the ITCZ forms just north of the Philippines. This also coincides with the time of the southwest monsoon. Thus, it is not surprising that we experience a lot of rain and bad weather during this time up to around November.

## Lesson 8.6 Global and Local Climate

**Climate** refers to the long-term weather condition in a given location. The general air circulation has direct implications on the global as well as our local climate.

Figure 8.24 shows the location of deserts and forests in relation to the global air circulation. Note the latitudes where sinking and rising air can be found. What weather phenomenon is usually associated with rising air? With sinking air?

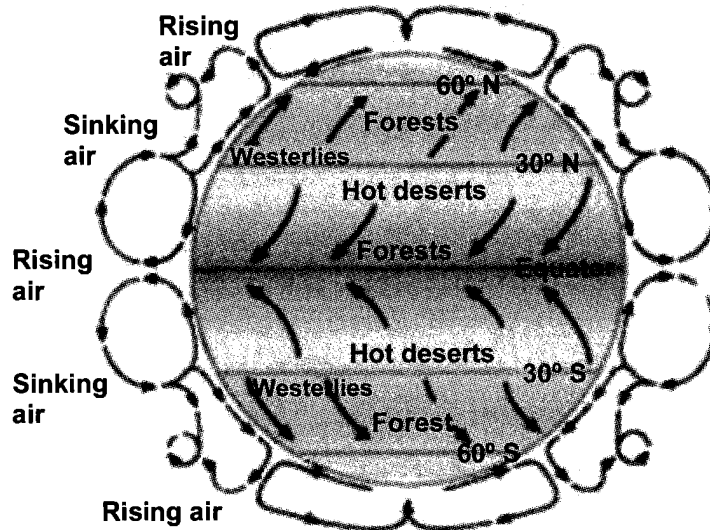


Figure 8.24 Effect of air circulation on climate

The regions with rising air tend to enjoy abundant rainfall. Most of the world's forests can be found in these latitudes. Among the major rain forests that can be found along the equator are the Amazon, Central African, and Indonesian rain forests.

Sinking air on the other hand, is dry and not conducive to cloud formation. Thus, most of the world's deserts are found in latitudes where there is sinking air. Examples are the Sahara desert in Africa, Arabian desert, Atacama desert in South America, Kalahari desert in South Africa, and Great Australian desert. The polar areas can also be considered as deserts since they cover vast areas with little or no vegetation.

You can see that on a global scale, climate is determined primarily by wind circulation.

## ***El Niño and La Niña***

Quite recently, we kept hearing about these two words over the radio and on television. What exactly are they?

The *El Niño* and *La Niña* are two different but related phenomena. They are phenomena that affect global climate. The ***El Niño*** is a disruption of the ocean-atmosphere in the equatorial Pacific Ocean.

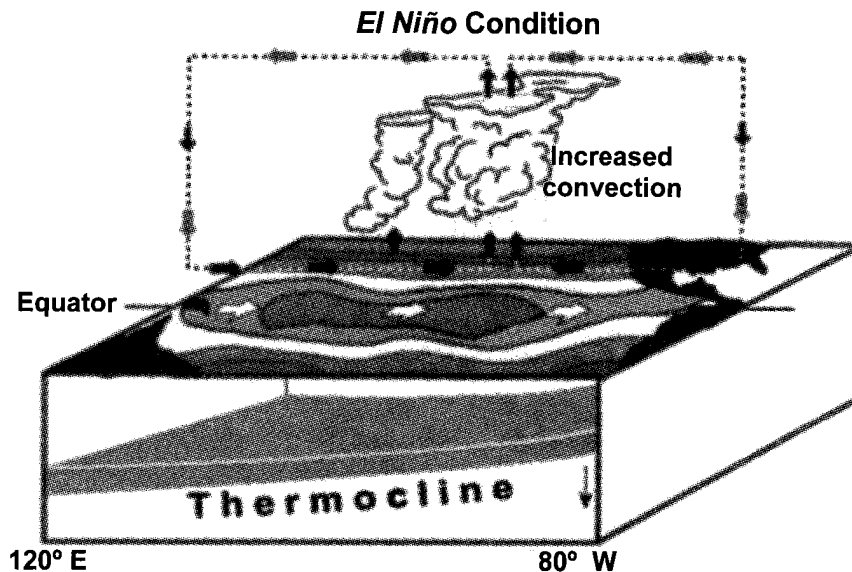


Figure 8.25 Change in conditions during an El Niño

Under normal conditions, the trade winds blow westward, piling up warm surface water in the western Pacific Ocean. The warm pool of water over this side of the Pacific Ocean is a rich source of water vapor. Convection in this area leads to increased cloud formation and rainfall. Thus, countries in the western side of the Pacific Ocean normally enjoy bountiful rain.

During an *El Niño*, the trade winds weaken and sometimes even reverse direction. This causes the warm pool of water to migrate toward the eastern Pacific. Convection and rainfall are similarly shifted eastward. This brings rain and bad weather to countries that would normally be dry. There is very little rain over the western Pacific because the sinking air in that region is warm and dry. Thus, occurrence of an *El Niño* generally causes drought in the Philippines.

The conditions during a ***La Niña*** are opposite to those of an *El Niño*. The trade winds get stronger, causing the warm pool of water to shift farther westward. This causes increased rainfall and greater occurrences of tropical cyclones in the western Pacific. Countries in the eastern Pacific, on the other hand, experience dry weather and drought.

The *El Niño* and *La Niña* are very good examples of how Earth's oceans interact with the atmosphere. A change in one system affects the other. Although the *El Niño* and *La Niña* are observed only at the Pacific Ocean, they affect climate patterns all around the world.

## The Ozone Hole

The ozone layer is important to life on Earth since it blocks harmful ultraviolet (UV) radiation from reaching Earth's surface. Later, you will learn that chlorofluorocarbons (CFCs) deplete ozone in the ozone layer.

The ozone hole that you often hear about is found over the South Pole (Antarctic). See Figure 8.26. The white area at the center means that no data has been collected for that region.

The **ozone "hole"** is not really a hole. It is just a region where ozone concentration is lower than the normal value.

Ozone concentration in the stratosphere is measured in terms of Dobson units (DU). Suppose the ozone in the stratosphere is brought down to sea level (at 0 °C), it would form a layer only 3 mm thick. This corresponds to 300 DU. The darkest shade in Figure 8.26 is about 100 DU (1/3 of the normal concentration).

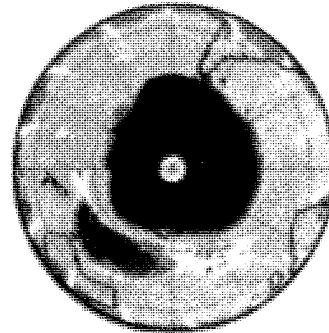
Ozone is found throughout Earth's atmosphere. It is thinnest over Antarctica. Why is the ozone hole found over Antarctica when there are so few people in this part of the globe to emit pollutants that deplete ozone in the ozone layer?

Recall that the general circulation of the atmosphere transports air from the equator to the poles. Thus, CFCs emitted in other parts of the world still find their way to the poles.

## Philippine Climate

Earlier you learned about the Philippine seasons and the different weather systems that prevail in the country. Let us now see how these affect the climatic conditions in the different parts of our country.

**The Ozone Hole Over Antarctica  
(September 24, 2003)**



*Figure 8.26 Dark-colored areas have low ozone concentrations. (Source: <http://www.theozonhole.com/September2003nasa.htm>)*

There is not much variation in our air temperature because we receive plenty of sunshine. However, there are variations in rainfall received for each region in the Philippines. We have four climate types based on rainfall. What are the four climate types? You will need Figure 8.27 in Activity 8.6.

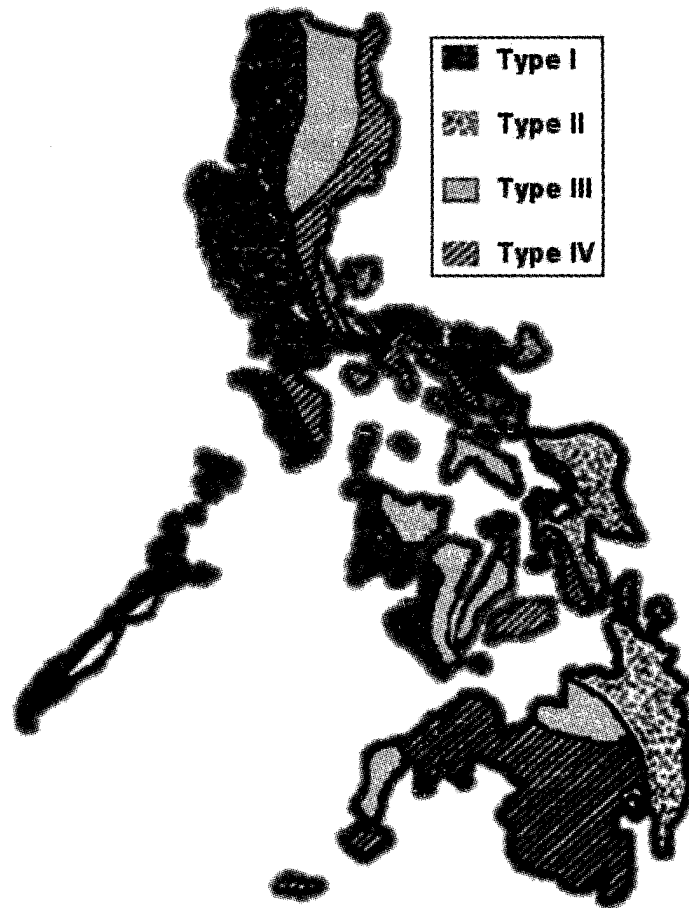


Figure 8.27 Corona's Philippine Climate Classification

### Activity 8.6 Four Climate Types in the Philippines

#### Materials

Philippine map

#### Procedure

1. Study Figure 8.27. The entire country is divided using four different shades. Each shade represents one climate type. The climate type shown here is based on Corona's classification.

2. Using a Philippine map, identify the places which have Type 1, Type 2, Type 3, and Type 4 climates. Present your result in tabular form.
3. The different climate types are described as follows:  
Type I: Dry from November to April and wet for the rest of the year  
Type II: Wet season all throughout the year  
Type III: There is almost no difference between wet and dry seasons  
Type IV: Rainfall is evenly distributed throughout the year
  - a. What climate type do you have in your place? Compare the description of the climate type with what you observe.
  - b. How is the rainfall pattern in the four climate types affected by the monsoon and the local terrain?

## Lesson 8.7 Cleaner Air

The atmosphere affects us in so many ways. However, we also affect the atmosphere. This is by way of emitting pollutants to it. In doing this, it is us, humans, who suffer.

### Air Pollutants

What are the gases that constitute clean air? Recall Table 8.1. Gases or particles introduced to the atmosphere at concentrations that are harmful to humans, animals, vegetation, or material, are considered **air pollutants**.

There are several types of air pollutants and they may occur in the form of solid particles, liquid droplets, and/or gases. Pollutants that are critical to controlling air pollution and for which guideline values are established for the protection of public health, safety, and general welfare are called **criteria pollutants**. The criteria pollutants in the Philippines and other common pollutants are listed in the following table with their descriptions and sources.

**Table 8.3 Common Air Pollutants**

<b>A. CRITERIA POLLUTANTS</b>	
<b>Pollutant/Description</b>	<b>Source</b>
<p><i>Total suspended particulates (TSP):</i> Tiny bits of solid matter of median diameter equal to 25 to 50 microns (or <math>\mu\text{m} = 0.000\ 001\ \text{m}</math>) suspended in the air for a long time. Ex. dust, smoke, metallic and mineral particles, soot, mist, and acid fumes or liquid droplets (from condensing vapor)</p> <p><i>Particulate matter, <math>PM_{10}</math>:</i> TSP that are 10 <math>\mu\text{m}</math> or less in diameter</p>	<p>Stationary and mobile sources, area source (dust from roads, ploughed croplands before planting, and burning of farm wastes)</p>
<p><i>Carbon monoxide (CO):</i> Colorless and odorless gas from the exhaust of motor vehicles where combustion of the fossil fuel is incomplete</p>	<p>Motor vehicles and some industrial processes. High concentrations may be found in enclosed places (garages, parking buildings especially in the basement), and even along the road during heavy traffic</p>
<p><i>Nitrogen dioxide (<math>NO_2</math>):</i> Light brown gas at low concentrations but imparts a darker shade to urban haze</p>	<p>Motor vehicles (especially those run by diesel engines) and by industry</p>
<p><i>Sulfur dioxide (<math>SO_2</math>):</i> Colorless gas, odorless at low concentrations but pungent at very high concentrations</p>	<p>Power plants, industry including petroleum refineries, smelters, paper mills, and chemical plants. A much smaller percentage is generated by motor vehicles</p>
<p><i>Ozone and other related oxidants:</i> Colorless gas, very reactive form of oxygen, a <i>secondary pollutant</i> since it is formed when UV light from the sun acts, in the presence of oxygen, on a mixture of nitrogen oxides and hydrocarbons, coming mostly from vehicle exhaust</p>	<p>Ozone results from chemical reactions between oxygen and a mixture of hydrocarbons and nitrogen oxides in the presence of sunlight (UV). The sources of hydrocarbons and nitrogen oxides which act as substrates for the formation of ozone are motor vehicles, factories, landfills, gas stations (in smaller amounts)</p>



<b>B. Other Common Pollutants</b>	
<i>Hydrocarbons:</i> Compounds consisting of carbon and hydrogen Ex. methane and benzene	Burning materials and from evaporation of gasoline and other compounds derived from petroleum
<i>Greenhouse gases:</i> Gases that allow incoming sunlight to pass through but prevent infrared terrestrial radiation to escape to outer space. They include carbon dioxide, water vapor, methane, and nitrous oxide	<i>Carbon dioxide:</i> fossil fuel combustion (for transportation and energy generation)  <i>Methane:</i> landfills, agricultural wastes, coal mines, rice paddies, and decomposing vegetation in water-logged areas (swamps)  <i>Nitrous oxide (N<sub>2</sub>O):</i> some industrial processes and from burning materials
<i>Depleters of ozone in the stratosphere:</i> Chemicals such as chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform that cause great damage to the ozone layer in the stratosphere	Industrial and household cooling, cleaning processes and equipment (Ex. refrigerators, home and car air conditioners, and dry cleaning procedure), fire extinguishers, hair net spray, and all other products that make use of a propellant, a liquid that vaporizes fast at low pressure
<i>Air toxics:</i> Include certain metals and nonmetals (Ex. lead, arsenic, asbestos, benzene), certain vapors from fuels and other chemicals. Lead particles of inhalable-size that occurs naturally in small quantities in soil, water, and air	Chemical plants, industrial processes, motor vehicle emission, and fossil fuels. In the case of lead, the sources include motor vehicles running on leaded fossil fuel, coal combustion, smelters, car battery plants, and burning of garbage containing lead products

Q8.9 Study Table 8.3. What air pollutants do you think are quite high in your community? Why do you say so?

Pollutants that come from the smokestacks of factories, power plants, or any isolated source of pollutants are said to originate from **point sources**. Moving vehicles are considered nonpoint or **line sources**. If the streets are close together or the sources of pollutants are close together in an area, then the area is considered a pollutant source and is called an **area source**.

## Air Pollution Dispersion

From the source, how does pollution disperse into the atmosphere? How high in the atmosphere can it get?

Pollutants are dispersed only up to a certain height in the atmosphere. The very thin layer of the atmosphere where pollutants are trapped is called the **mixing layer**.

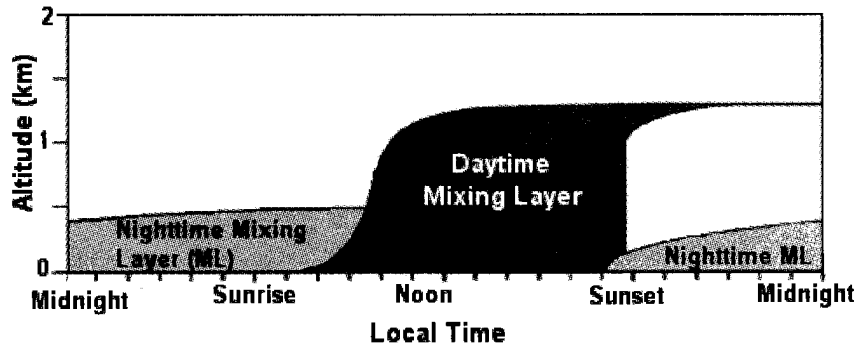


Figure 8.28 Relative height of the nighttime and daytime mixing layer (Stull, 1988)

At nighttime, the height of the mixing layer (ML) is determined by wind speed. The mixing layer cannot get higher than 1 km.

At daytime, pollutants are dispersed from the ground by convection. Recall what you learned about convection in Lesson 4.7. When Earth's surface gets heated by sunlight, the air just above the ground becomes hotter than the air farther from it. The heated air is less dense and hence more buoyant than the air farther from the ground. It then moves upward by convection but only up to a certain height. Under high pressure, in the tropics, the maximum height of the mixing layer is about 2 km.

There are many factors that affect the height of the daytime mixing layer. One factor is the temperature of the ground. The hotter the ground, the higher is the mixing layer. It is expected then that the mixing layer is much lower in the early morning until mid-morning and higher from noon-time until the afternoon. Shown in Figure 8.28 is the relative height of the

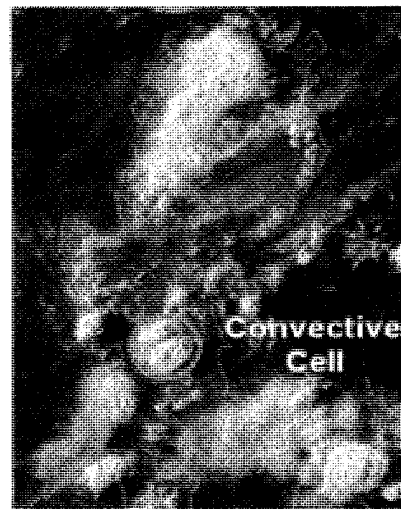


Figure 8.29 The convective cell over Metro Manila on May 3 reduced the mixing layer height from 16:00 LST very significantly as shown in by the dashed line in Figure 8.30.

nighttime and the daytime mixing layer.

In a research conducted by G. Tubal et al., on the mixing layer over Metro Manila in May of 1999, they observed that the height of the mixing layer was greatly reduced when there was sea breeze and when there were convective cells or clouds over the area like the one shown in Figure 8.29. As an example, the occurrence of sea breeze on May 3 resulted in a very much lower mixing layer as compared to that on May 2. See Figures 8.30.

The height of the mixing layer has a great impact on pollution concentration. You will discover this in Activity 8.7.

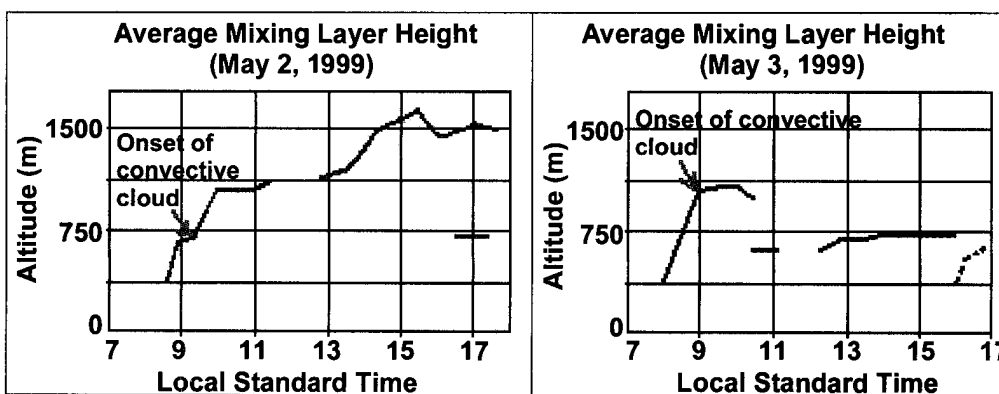
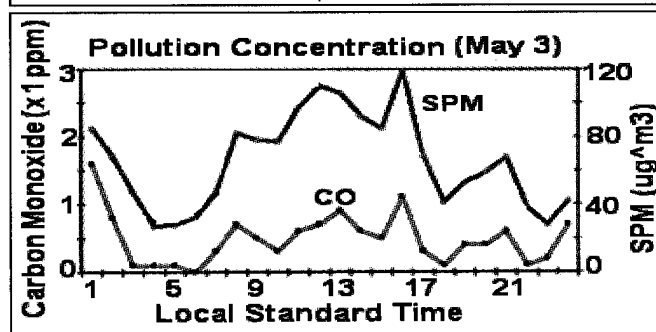
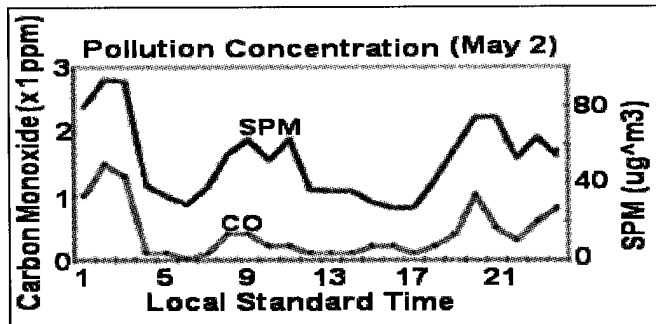


Figure 8.30 The average mixing layer (ML) height on May 2 and 3, 1999. The much lower ML from around 10:30 a.m. until 4:00 p.m. on May 3 was caused by sea breeze effects.

### Activity 8.7 Mixing Layer Height and Pollution Concentration

#### Procedure

1. Refer to Figure 8.30. Compare the mixing layer height from noontime until 4:00 p.m. (or 16:00 LST) on May 2 and May 3.
  - a. How much higher is the mixing layer height in the afternoon on May 2 than that on May 3?
  - b. Compare the volume of the atmosphere in which pollutants are dispersed when the mixing height is low and when it is high.
  - c. When do you expect the pollution concentration higher, in the afternoon of May 2 or on May 3?
2. Given in the next page is the pollution concentration on May 2 and May 3, 1999. Compare the two graphs.



- On what day is the pollution concentration higher? Why?
- Consider the pollution concentration at around 16:00 LST. What could have caused the spike in the pollution concentration during this time?
- Relate pollution concentration and the height of the mixing layer.

When the mixing layer is high, the pollution concentration is low. When the mixing layer is low, the pollution concentration is high as shown in the activity figure. This is because pollutants are dispersed in a much less volume of the atmosphere.

## Effects of Air Pollution on Human Health

Do you like riding in a jeepney plying traffic-congested areas? Do you want to be in an enclosed room where there are many people smoking? Why?

Cigarette smoke is a pollutant because it contains toxic substances such as nicotine organic pollutants and hydrogen cyanide. Some researches link cigarette smoking with coronary heart disease and lung cancer. Non-smokers exposed to cigarette smoke have high risk of developing lung cancer and respiratory diseases, especially among children.

Some pollutants have been linked to diseases of the respiratory organs. Unfortunately, there are lots of pollutants in the air we breathe that affect our health. Let us just consider the effects of criteria pollutants on human health. See Table 8.4.

**Table 8.4 Health Effects of Air Pollutants**

<b>Pollutants</b>	<b>Effects</b>
Particulate matter	Exposed person is more susceptible to respiratory diseases; PM <sub>10</sub> from diesel smoke can cause cancer.
Carbon monoxide	Greatly interferes with oxygen absorption from the blood that results to dizziness, headaches, fatigue to persons exposed to low concentrations. It may cause death at high concentrations.
Sulfur dioxide and nitrogen dioxide	Increased respiratory diseases and decreased lung function of exposed person, making breathing more difficult, especially for those with asthma.
Ground-level ozone	It is irritating to the eyes, nose, and throat. It causes lung and respiratory disorders.
Air toxics (asbestos, arsenic, benzene)	These are suspected to cause cancer, respiratory ailments, birth defects, reproductive disorders, and other serious health problems.
Lead	Affects the brain (mental development), central nervous, kidney, cardiovascular, endocrine, and reproductive systems

Q8.10 Read more about the effects of the different pollutants on your health. Which among the pollutants, do you think, will affect you the most? Why do you say so? What plan of action will you take to minimize your exposure to such a pollutant?

## Other Effects of Air Pollution

### Acid Rain

**Acid rain** is simply rain which is acidic. The rain becomes acidic when some gases such as carbon dioxide, sulfur dioxide, and nitrogen dioxide in the atmosphere dissolve in rainwater. Sulfur dioxide and nitrogen dioxide in the air also cause smog that reduces visibility. Sunlight increases the rate of these reactions.

Calcium carbonate (like in limestone) reacts readily with acid. In the ground, acidic water does not only affect calcium carbonate but also soil nutrients such as magnesium and potassium. These dissolve faster than usual in acidic water. Thus, acid rain increases leaching of nutrients from the soil. This deprives trees and other plants of needed nutrients for their growth. Acid rain makes lakes and streams acidic. As a result, they harm not only humans but also vegetation and aquatic life.

Q8.11 Discuss how a coal-fired power plant increases the acidity of rainwater in that locality.

Q8.12 Acid rain corrodes metals as well as marble monuments and statues. Explain why it can corrode marble monuments and statues.

### Enhanced Greenhouse Effect

What is greenhouse effect? Is greenhouse effect important or disadvantageous to life on Earth? What is enhanced greenhouse effect?

The portion of sunlight that reaches Earth's surface is absorbed and converted into energy of longer wavelength (that is, infrared, or heat). This is reradiated by the ground back to the atmosphere. Greenhouse gases present in the troposphere do not absorb sunlight but absorb infrared radiation, thereby preventing energy from escaping to outer space (Figure 8.31). This phenomenon is called the **greenhouse effect**.

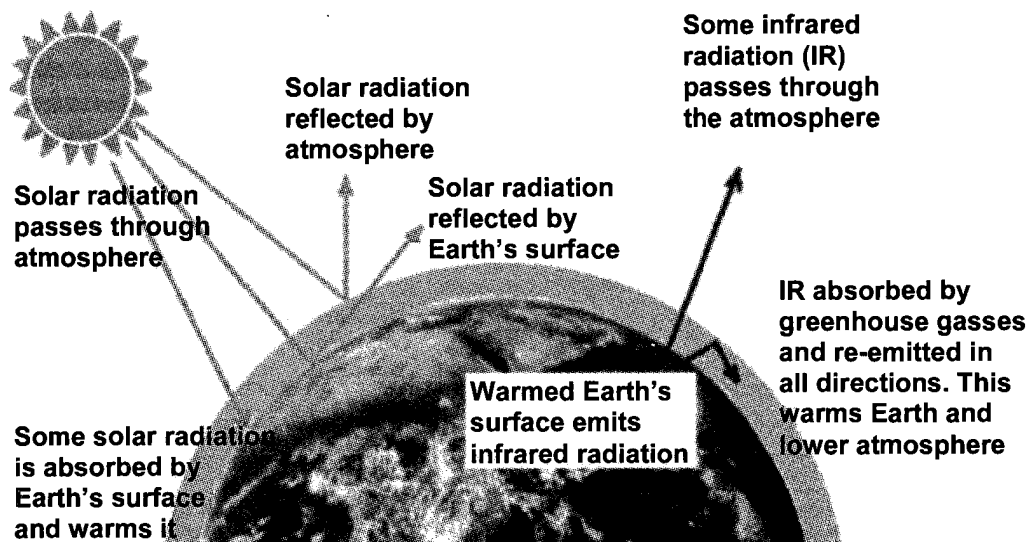


Figure 8.31 Greenhouse effect

The Greenhouse effect is important to life on Earth, since it maintains the temperature needed to support life. Having the right amount of greenhouse gases is what gives Earth the right temperature for people to live.

Due to the increasing use of fossil fuels, burning of forestlands to increase agricultural production, decaying of agricultural products, and other human activities, the concentration of greenhouse gases in the atmosphere has been increasing, resulting in an “enhanced greenhouse effect” which is often referred to as **global warming**.

Scientists say that a hotter world will make “extreme weather”—referring to heat waves, droughts, and floods that may cause death to humans. Increased temperature also affects other living things. Some aquatic species have moved their ranges towards colder regions. Migratory patterns of animals are disrupted. Higher temperatures are conducive to the spread of disease organisms, or **pathogens**, that affect plants, animals, and humans.

### **Photochemical Smog**

**Tropospheric ozone** (a molecule of 3 oxygen atoms ( $O_3$ ) bound together) is a major constituent of photochemical smog (contraction of smoke and fog) which reduces visibility. Do you know that ozone is a powerful oxidizing agent? It is said to be the most injurious air pollutant to plant life. It can damage materials such as rubber, nylon, plastics, dyes, and paints.

### **Ozone Hole**

Ozone is mostly concentrated in the so-called “**ozone layer**,” the lower portion of the stratosphere about 25 to 30 km from Earth’s surface. In this region, ozone acts as a shield to protect Earth’s surface by absorbing harmful ultraviolet radiation. The ultraviolet radiation absorbed is converted to heat.

Without this shield, we would be more susceptible to skin cancer, cataracts, and impaired immune systems. Although the stratospheric (good) ozone only represents a tiny fraction of the atmosphere, it is crucial for life on Earth.

Chemicals that destroy ozone cause thinning of the ozone layer in the stratosphere, creating what is called ozone hole over the South. The phenomenon allows more ultraviolet radiation from the sun to reach Earth’s surface, making the environment under the ozone hole a risky place to live in.

Q8.13 List some chemicals that deplete ozone in the ozone layer and their sources.

Q8.14 Why is ozone in the lower atmosphere considered a pollutant? Why is it not a pollutant in the upper atmosphere?

## Controlling Air Pollution

Figure 8.32 shows the average annual pollution concentration of  $PM_{10}$  in Metro Manila in 2000. The maximum acceptable average annual pollution concentration for  $PM_{10}$  is  $90 \mu\text{g}/\text{m}^3$ . Most busy cities in the Philippines likewise exceed this acceptable limit. Knowing the bad effects of air pollution, there is a need for us to act now to reduce air pollution.

The best way to reduce air pollution is to control emission from its source. You have a responsibility in keeping the air you breathe clean. In order for you to do your share, you must be aware where air pollutants come from and how these can be reduced. Which pollutant sources can be found in your community? Do Activity 8.8.

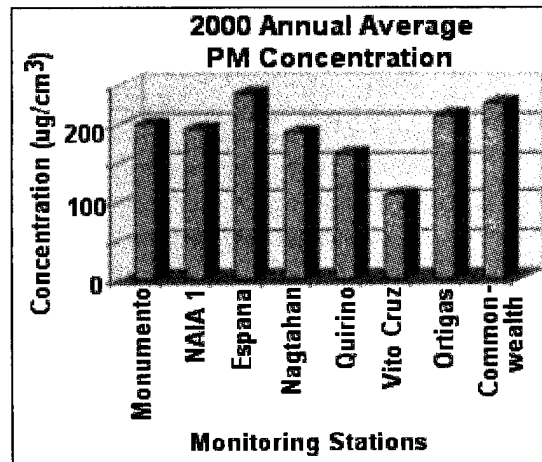


Figure 8.32 Pollution concentration of  $PM_{10}$  in Metro Manila in 2000

### Activity 8.8 What Pollutes My Community?

#### Procedure

1. List ten human activities or natural events that bring about air pollution in your community.
2. Rank the identified sources of pollution in a scale of 1 to 10, with 1 as contributing the most pollution and 10 the least. Be sure to explain why you ranked the number one source of pollution as such.
  - a. What do you recommend to reduce or prevent pollution from the different sources in your community?
  - b. What are the actions being done to reduce and prevent air pollution in your community?

What are the different ways of reducing pollution caused by vehicles or mobile sources? Of course, the best way to do this is not to use vehicles at all! This might sound impossible but this can be done if you just have to travel short distances. Mass transport system is also one way of reducing vehicles on the road. The Light Rail Transit (LRT) and Metro



Rail Transit (MRT) systems have significantly reduced the number of small vehicle requirements in Metro Manila. Car pooling or sharing a ride also reduces vehicles on the road.

But if vehicles are to be used, there are still many ways by which pollution can be greatly reduced. A four-stroke motorcycle is less polluting than a two-stroke engine. While proper vehicle maintenance and good driving habits can help reduce air pollution, the use of cleaner fuels can do a lot more.

Q8.15 Research on cleaner fuel alternatives for the transport sector. Describe how these can be used.

You can do something to reduce emissions from factories and power generation plants by being vigilant and by reporting to authorities when you notice that these are emitting black smoke. Do you know that you can do much with regards to the emissions from power plants? You can save electrical energy as a way of reducing emissions from power plants. In addition, using nonpolluting alternative energy sources for electrical energy generation not only reduce but also prevent the emission of pollutants. Some energy sources are much less polluting than fossil-fired thermal power plants as you might recall from Table 4.1.

Greening is also one way of reducing air pollution. There are plants that are effective absorbers of sulfur dioxide and nitrogen dioxide and can remove them from the air. Examples are ipil-ipil, picara, yellow bell, chichirica, molave, yemane, San Francisco, caballero, pandan, Mollucan sau, African tulip, bandera española, campanilla, and bougainvillea.

## **The Philippine Clean Air Act of 1999 (R.A. 8749)**

The main purpose of Republic Act (R.A.) 8749 is to assure every Filipino that the air we breathe is clean and to guarantee our right to breathe clean air. Through a comprehensive program on air pollution management, the focus of this law is primarily on pollution prevention rather than control. It envisions a multisectoral participatory approach, including all Filipinos, to achieve and maintain clean air in the Philippines. It should be emphasized that it is everybody's responsibility to help in achieving clean air.

R.A. 8749 emphasizes pollution prevention. To be able to discuss this objectively, you have to know the problems in your community and where the problems come from. Recall Activity 8.8. Which situation did you consider "most serious air pollution problem" in your community—dark smoke from moving vehicles, dust from the road or industries, unpleasant smell of decaying or burning wastes, or black smoke from chimneys of factories? What activities are being done to control pollution?

Q8.16 What do you think are the agencies responsible in cleaning the air? What are their functions?

Monitoring levels of pollution can control pollution. Different agencies coordinate and are tasked to implement the laws and monitor pollution levels. Using technological devices may also control pollution. What is better than controlling pollution? You must have heard of the saying: prevention is better than cure. R.A. 8749 describes a comprehensive program to prevent pollution. Preventing air pollution means doing something even before the event occurs.

More ecological ways of handling wastes such as reduction from source, recovery of waste components, and recycling could reduce pollution. Closing of open dumps and using nonburn technologies will reduce and eventually prevent gaseous and particulate emissions. Requiring vehicles to undergo emission testing and using clean fuels will remove smoke belchers on the road. Banning cigarette smoking in public places and greening the communities will help clean ambient air or air within breathing levels.

Q8.17 Listed above are but some ways of preventing air pollution emission. List other activities that can prevent air pollution. Which activities from your list can your class do to help prevent air pollution? Outline your plan of action.

### **Home Activity**

Depending on your interest and skill, design a poster, write a slogan, or compose a song to help create awareness of the Clean Air Act. Plan a program on when and how your IEC materials will be used.

## **SUMMARY**

The details of the processes that bring about weather are rather complicated. Even with the recent technological advancements, it is still very difficult to make accurate weather forecasts. However, the basic principles that bring about weather are quite simple.

The sun provides the primary driving mechanism that brings about weather. Tropical areas receive more energy per unit area compared to the polar areas. This imbalance results in a transfer of energy from the equator to the poles. The Earth, its atmosphere, and its oceans interact to bring about these processes.

One-third of the excess energy from the equator is transferred to the polar areas. Another one-third is transferred through oceanic circulation. The remaining one-third is transferred through the phase change of water vapor.

Without an atmosphere, energy absorbed by the Earth's surface becomes easily emitted to outer space. The absorption of infrared radiation helps slow down this release of energy—making temperatures near the surface more conducive to life.

The composition of the atmosphere and the processes going on in it make the existence of life on Earth's surface possible. However, there are activities on Earth, especially those created by humans, that alter the atmosphere's composition and processes. An example is the emission of pollutants to the atmosphere. In the end, it is also humans who suffer because part of the atmosphere where they move about deteriorates.

## SELF-TEST

### I. Multiple-Choice Items

Choose the letter of the correct answer.

1. Relative humidity provides an indication of the
  - a. probability of rainfall.
  - b. water vapor content of air.
  - c. degree of saturation of air.
  - d. rate of condensation of water vapor.
  
2. What prevents the mercury in a barometer from falling completely out of the glass tube?
  - a. pressure exerted by the glass tube
  - b. high pressure inside the glass tube
  - c. pressure exerted by the atmosphere
  - d. pressure exerted by the mercury in the reservoir
  
3. Which of the following is usually a sign of bad weather?
  - a. formation of cirrus clouds
  - b. steady decrease in pressure
  - c. steady increase in pressure
  - d. decrease in relative humidity
  
4. Why are clear nights usually colder compared to nights with cloudy skies?
  - a. There is less water vapor during clear nights.
  - b. The Earth more readily loses heat to outer space.
  - c. The ground releases more heat during cloudy skies.
  - d. Less heat is reflected toward the Earth by the moon.
  
5. In general, you would expect to find desert areas in zones of
  - a. high atmospheric pressure.
  - b. low atmospheric pressure.
  - c. prevailing easterly wind.
  - d. prevailing westerly wind.

6. The southwest monsoon usually causes rain and bad weather. Why is this so?
- Typhoons do not originate from the Pacific Ocean.
  - It passes over relatively cold waters in the Pacific Ocean.
  - It passes over warm and moisture-rich air of the South China Sea.
  - There are not as many mountains in the eastern side of the Philippines.
7. The wet and dry bulb readings of a hygrometer are recorded in the table below for four different locations. The RH readings for four different locations are given below.

Location	L1	L2	L3	L4
Dry bulb (°C)	22	33	25	24
Wet bulb (°C)	18	26	23	23
Difference	4	7	2	1
Relative Humidity (%)	78	68	90	95

In which location can the air absorb more water vapor?

- L1
  - L2
  - L3
  - L4
8. On a beach, the wind direction during the day is usually the reverse of wind direction at night. Which of the following statements best explains this?
- There is more water in the sea than on land.
  - Land heats up faster than water during the day and it also cools faster at night.
  - The water remains at about the same temperature all throughout the day.
  - This is usually an indication that an El Niño event is under way.
9. When is pollution concentration likely to be high?
- early morning
  - early afternoon of a clear sunny day
  - when there is a prolonged sea breeze
  - when there are convective clouds over the area
- I and III only
  - II and IV only
  - I, II, and III only
  - I, III, and IV only

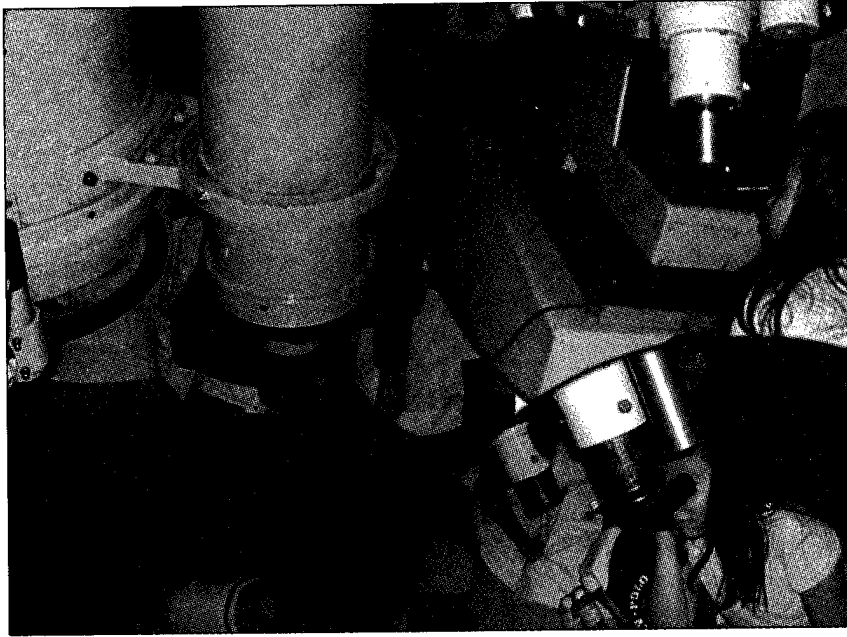
## II. Open-ended or Constructed - Response Items

Answer the following.

- Differentiate pollution prevention and pollution control.
- When are carbon dioxide and ozone beneficial to life on Earth? When are they harmful? Explain.
- Cite activities that reduce air pollution. Explain.

## Unit IX

### Earth and Its Neighbors



Our planet, Earth, is part of the complex organization and collection of heavenly bodies we call the universe. The universe includes the vast gaseous space, galaxies and stars, planetoids, moons, and the solar system to which Earth belongs.

How big is the solar system? What do we know about the members of the solar system and other bodies in space? How do these bodies in space affect life on Earth? How does the National Aeronautics Space Agency (NASA) study the planets and other bodies in space?

Mars has been the latest target of NASA exploration. What new information about Mars has been gathered? What do these studies say about the existence of life on Mars?

People are generally interested about the existence of life outside of our planet. Some people are even greatly influenced by the position of stars and planets in the belief that these can affect our future. Is this true or not?

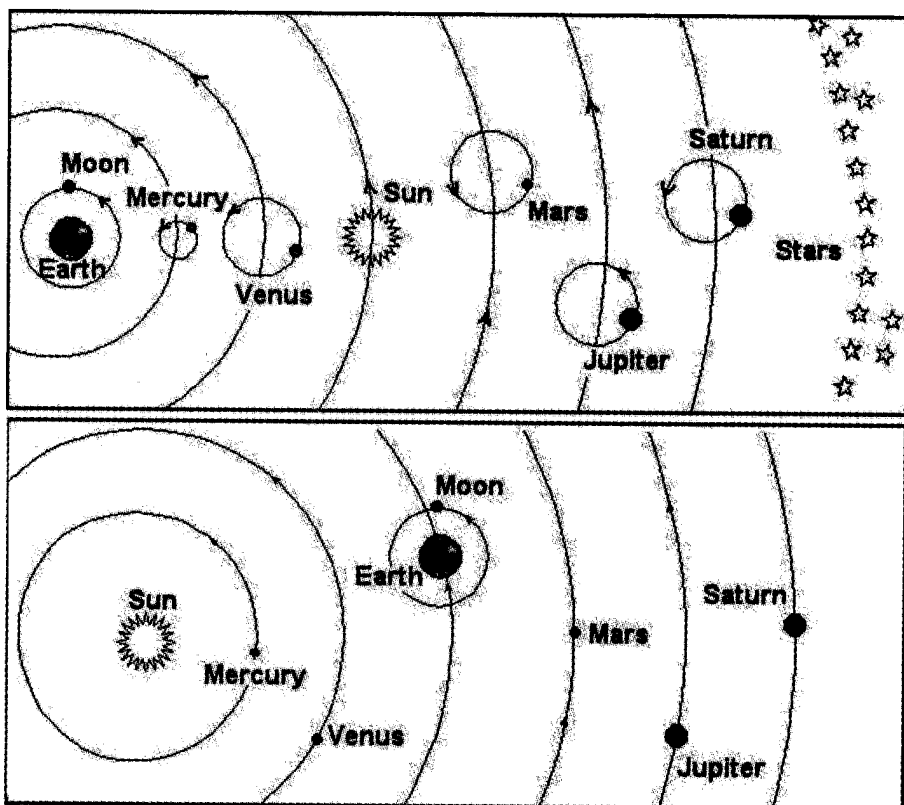
This unit will help you analyze information about Earth's neighbors. Then you can make decisions on whether or not to accept as truth facts passed on to you.

## Lesson 9.1 A Quick Look at History

Ages ago, people believed that all heavenly bodies revolved around Earth. This observation was based on the movements of these bodies across the sky. It was also reflective of the natural inclination of people at that time to think of oneself and country as the center of the universe. Later, the concept of "self" was broadened and people regarded the whole planet as the center. This theory was upheld by early scientists like Ptolemy, Aristotle, and other Greek philosophers who lived between 350 and 400 B.C.

In 1543, a Polish astronomer, Nicholas Copernicus, proposed the theory that the sun was the center around which all the planets revolved. Many chose not to believe him because to adopt the idea of Copernicus would have meant questioning Aristotle's authority. Besides, the radical idea of a sun-centered system was against the Church's doctrine that the rightful place of humans in the universe is at the center.

Study the figure below and look for major differences between the two systems of viewing the universe.



*Figure 9.1 The Ptolemaic system (above) and the Copernican scheme (below)*

- Q9.1 Based on the Ptolemaic system, where is Earth in relation to the other planets and the sun?
- Q9.2 Based on the Copernican scheme, where can you find the center of the universe?
- Q9.3 In your own words, state the major difference between the Ptolemaic view and Copernican view of the universe.

During the 17<sup>th</sup> century, an Italian astronomer, Galileo Galilei, using a telescope, made several important observations that clearly supported the sun-centered theory of Copernicus. He wrote books and published letters on his initial findings. His scientific studies contradicted popular sentiments and beliefs. He was put on trial and was later forced to publicly deny his views. Refusing to do so, he was publicly chastised and placed under house arrest for the rest of his life.

Now, we know that the sun, the planets that revolve around it, and the moons around their respective planets make up our *solar system*. The major members of the system are the planets. The minor members are the asteroids, comets, and moons.

#### Home Activity

Start reading or interviewing people about the latest space explorations, especially of Mars. How are these studies done? What information about Mars is new?

## Lesson 9.2 The Sun and the Planets Around It

The sun is the major source of energy, not only of Earth, but also of the other bodies that travel around it. It is the nearest and largest star to Earth. The sun is not the solid matter it appears to be. It is actually a ball of very hot gases made up mostly of hydrogen and helium.

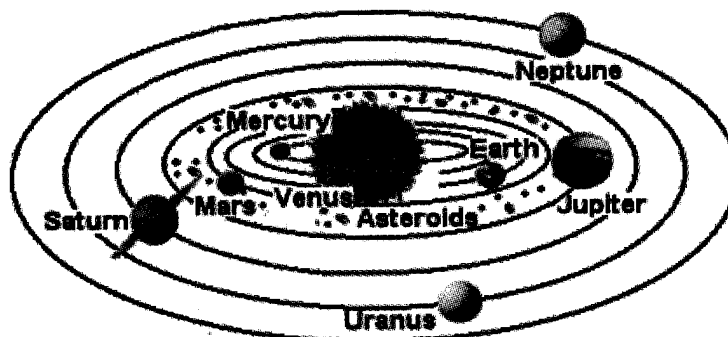


Figure 9.2 The solar system

The sun and the bodies that revolve around it make up our planetary system. Table 9.1 shows some of their physical characteristics. Study them to be able to answer the questions that follow.

**Table 9.1 Some Physical Characteristics of the Sun and the Planets**

Planetary Body	Diameter (km)	Mean Distance from the Sun (million km)	Observed Components of Their Atmosphere
Sun	1 400 000	----	H, He
Mercury	4 800	58	No gases
Venus	12 100	108	CO <sub>2</sub>
Earth	12 756	150	N <sub>2</sub> , O <sub>2</sub> , H <sub>2</sub> O, CO <sub>2</sub>
Mars	6 794	228	N <sub>2</sub> , NH <sub>3</sub> , CH <sub>4</sub> , He
Jupiter	142 984	778	H <sub>2</sub> , NH <sub>3</sub> , CH <sub>4</sub> , He
Saturn	120 536	1 427	NH <sub>3</sub> , H <sub>2</sub> , CH <sub>4</sub>
Uranus	51 100	2 870	CH <sub>4</sub> , H <sub>2</sub> , He
Neptune	42 200	4 497	CH <sub>4</sub> , H <sub>2</sub> , He

- Q9.4 What planet is nearest to the sun? Do you expect to find living things similar to those that exist on Earth in that planet? Why or why not?
- Q9.5 Why are there no gases in Mercury? (Hint: molecules move fast at high temperatures.)
- Q9.6 Why is Venus considered the twin sister of Earth?
- Q9.7 Venus contains high amounts of carbon dioxide. Would its temperature be higher or lower than the temperature of Earth? Explain your answer.
- Q9.8 How many times is Jupiter bigger than Earth? Which possesses greater gravity, Jupiter or Earth?
- Q9.9 Which planet contains gases similar to the sun? Is it possible and practical for Earth to obtain energy from the gases found in these planets? Why or why not?
- Q9.10 Planets revolve around the sun. Which planet has the smallest orbit? The largest orbit? How did you arrive at your answers?
- Q9.11 Is it possible for planets to collide with one another? Explain your answer.

In the 16th century, Johannes Kepler, a German mathematician and astronomer, supported the theory of Copernicus that planets revolved around the sun. But he discovered something else. After a long and careful analysis of observations made by earlier astronomers, Kepler realized that planets do not orbit in perfect circles. Instead, planets move around the sun in an oval orbit or ellipse. What is an ellipse? Find out by doing Activity 9.1.



### **Activity 9.1 Visualizing an Ellipse**

#### **Materials**

2 thumbtacks	pencil
a 40-cm string	newspaper or cardboard
bond paper	

#### **Procedure**

1. Fold the newspaper. Put the bond paper on top. Press the two thumbtacks, about 10 cm apart, on the paper.
2. Make a loop on the string by tying the two ends together. Place the loop of string over the thumbtacks.
3. Put the pencil inside the loop and pull the string to one side. Using the string as a guide, draw a circle on the paper. With your other hand, press the thumbtacks.
4. Make two more ellipses with the thumbtacks, 5 cm apart, side by side with each other. Follow the above procedures and use bond paper for every ellipse that you make.
  - a. Compare the ellipses you drew. When is the ellipse more circular—when the thumbtacks are closer to each other or when they are far apart?
  - b. Suppose one thumbtack represents the sun and the pencil represents a planet going around the sun. Is the distance of the planet from the sun the same at all points in its orbit? Explain your answer.

All planets follow elliptical orbits around the sun. In an elliptical orbit, the distance of a planet from the sun changes at different points in its orbit. The planet may be nearer or farther away from the sun. It moves slowest when it is farthest from the sun. Its speed then increases, reaching its maximum when it is closest to the sun.

In August to September 2003, Mars made its closest approach to Earth in about 60 000 years. The next time Mars will come close to Earth will be in August 2287. With the naked eye, Mars appeared at sunset as a bright orange light. Using a telescope at 75X magnification, Mars was about the size of a five-centavo coin held at arm's length. Surface markings were faintly visible while night sky watchers got a glimpse of the South polar ice caps. Why did this happen? Again, it is due to the planets' elliptical orbits. This means that the distance of Mars from the sun was

closest during these months. In addition, Mars formed a straight line with Earth and the sun.

## Lesson 9.3 How Big Is the Solar System?

Can you imagine how big the solar system is? With your classmates, make a scale model of the solar system to visualize the size of the solar system compared to the sizes of the individual planets. Your teacher will assign groups who will make the model of the sun and each of the planets.

### Activity 9.2 Making a Model of the Solar System

#### Materials

art paper or manila paper and crayons  
plastic or papier-mache balls

#### Procedure

1. Make a paper flag for the planet assigned to your group. Label the flag with the planet's name.
2. Choose a plastic ball or make a papier-mache ball that is reasonably close to the specified size of the planet assigned to your group. Use the diameter data in Table 9.1. It is not necessary to have very accurate measurements.
3. Go out into the school yard or playground. Let the group that made the sun put their model on the ground. Let the groups that made the planets locate their positions from the sun and stick their flags beside the planet at the appropriate distance.

If the playground is big, stick your flags anywhere around the sun to simulate the planetary orbit they follow but make sure that the distance from the sun is correct. If it is not possible to do this, simplify the scale model so that everything follows a straight line. Remember that because each planet goes around the sun in its own orbit, the planets are **never** in a straight line.

The solar system is actually mostly empty space. What other evidence do we have to claim that this is so? Look at Table 9.2. How much time does it take for light or radio waves to travel from the sun to each planet? How much time does it need for a spaceship to reach Earth's moon? Why do you think is it very cold in Jupiter or Neptune?

The table also emphasizes the large distances between planets and the sun. It also shows the very small sizes of the planets compared to their distances from the sun. Thus, the model of the solar system you find in books cannot be accurate both in size and in distance. When the size is accurately scaled, the distance suffers, and vice versa.

**Table 9.2 Travel Time for Sunlight to Reach the Planets and of a Spacecraft from Earth to the Planets**

Planet	Light Time from Sun	Spacecraft Travel
Mercury	3.2 min	5 mo
Venus	6 min	3 mo
Earth	8.3 min	---
Earth's Moon	1.3 s from Earth	3 days
Mars	12.7 min	8 mo
Jupiter	43 min	1.5 yr
Saturn	1.3 h	3.2 yr
Uranus	2.7 h	8.5 yr
Neptune	4.2 h	12 yr

Did you know that our solar system has a minor planet (asteroid) called *Biyo* named after a biology teacher from the Philippine Science High School in West Visayas (Iloilo City)? Dr. Josette Biyo was given a teacher award in the International Science Fair in Kentucky, United States of America in 2002 for her innovative teaching strategies and commitment to science education in the country, besting over 4 000 contestants from all over the world.

Between Mars and Jupiter lies the asteroid belt comprised of chunks of rocky and metallic material with sizes ranging from over 200 km to less than 1 km. *Biyo* is about 4 to 9 km in diameter. Only 26 asteroids are larger than 200 km. The combined mass of all the asteroids is less than the moon's mass.

## Lesson 9.4 The Earth, Sun, and Moon

Most of the planets have natural satellites moving around them. Shown here is a table of the number of moons of the planets in the solar system (as of December 2003).

In 1969, two Americans, Neil Armstrong and Edwin Eugene Aldrin, Jr., became the very first men to land on the moon. You may ask, "Why did they go to the moon?" Understand that the trip to the moon is not only difficult, but also a very expensive undertaking. Why is there so much interest in the moon anyway?

The moon is that one body in space nearest to Earth and its presence and location in the universe greatly affects Earth. One such effect is the **eclipse**—a scientific phenomenon best described by the "disappearance" of the sun, as viewed from Earth.

### Eclipse

Many years ago, a great war was about to begin. The two warring armies faced each other across a vast plain. Suddenly, the sky turned dark. The sun seemed to be swallowed up. The armies thought that the sun's disappearance was a signal to stop the war. Although the sun soon reappeared, the frightened soldiers went home without fighting.

The soldiers witnessed an eclipse of the sun.

Q9.12 What do you know about eclipses? Draw the position of the sun, Earth, and moon when a solar eclipse occurs.

Q9.13 What beliefs do you know about eclipses?

- If you are not familiar with any story, ask your parent or any adult in the community.
- Is there any scientific basis to this belief? Why or why not?

A **solar eclipse** occurs when the moon comes between the sun and Earth. The moon covers the sun from the view of observers on Earth. A solar eclipse occurs only during the new moon phase. A total solar eclipse was observed on October 24, 1995 in Languyan, Tawi-tawi. In other parts of the country only a partial solar eclipse was observed—a small portion of the face of the sun was covered by the moon.

**Table 9.3 The Planets and Their Moons**

Planet	Number of Moons
Mercury	0
Venus	0
Earth	1
Mars	2
Jupiter	61
Saturn	31
Uranus	27
Neptune	13

\*Source: <http://www.planetary.org/learn/solarsystem/moons.html>

The eclipse of the moon, called **lunar eclipse**, occurs when Earth comes between the moon and the sun. The shadow casts by Earth falls on the moon. If it were not for the refraction of light by Earth's atmosphere, the moon would seem to disappear. Instead, the moon takes on a reddish to yellowish appearance. A lunar eclipse can occur only during a full moon phase.

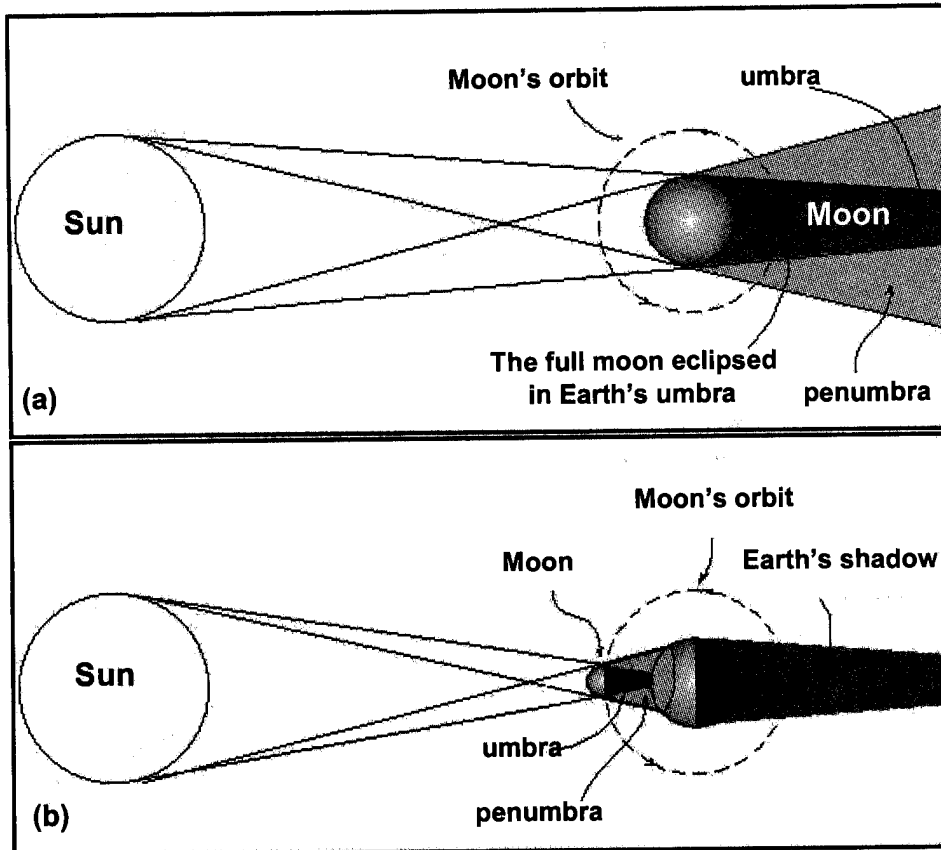


Figure 9.3 Comparing (a) lunar and (b) solar eclipses. Describe the phenomena in your own words.

## Tides

The relative positions of the sun and the moon to Earth have also been found to affect the surface waters on Earth. They cause **tides**, or the rising and falling of water, at the seashore.

If you observe the sea for a whole day, you will notice that tides occur twice a day, once every twelve or more hours. We therefore experience two high and two low tides.

Tides are caused mainly by three factors: 1) the rotation of Earth; 2) the gravitational attraction between the moon and Earth; and 3) the gravitational attraction between the sun and Earth.

The mass of the sun is many times larger than that of the moon, but the moon is so much nearer to Earth than the sun, therefore, we expect that the moon's effect on tides is more than the effect of the sun.

When the sun and moon are aligned (new and full moon) unusually high and low tides are observed. Their combined gravitational pull causes the water on opposite sides of Earth to bulge. Tides that occur during such times are known as spring tides.

Why does the water bulge on the side of the Earth facing the moon?

Moon's gravity experienced by Earth decreases with increasing distance from the moon. The spherical shape of Earth places some ocean waters closer to the moon than other areas. The ocean waters that are closer to the moon experience a greater gravitational force than those that are farther away. This is also true for the solid part of Earth. But since water flows more freely than the solid part, the bulging of the ocean waters is more evident. The bulge is greatest where the water is closest to the moon (usually near the equator) and decreases towards the poles.

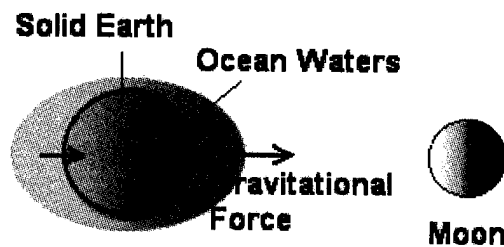


Figure 9.4 Gravitational force of moon on Earth produces tides

The tidal bulge on the side of Earth facing the moon is due to the moon's gravitational pull. What causes the tidal bulge on the opposite side of Earth?

This is also due to the decrease of gravitational force with distance. The side of Earth facing the moon experiences a greater gravitational pull than the opposite side. In a way, Earth is pulled away from the water on the far side, making the ocean, sea, or lake basin deeper than it normally is. This makes the water rise.

The sun exerts a greater gravitational force on Earth than moon does. However, due to its much greater distance from Earth, the difference of its gravitational force on the different parts of Earth does not vary much. So its effect on Earth tides is not as significant as that of the moon. However, if the moon and the sun are all aligned with Earth, ocean tides are more significant than when they are not aligned. The tides that occur when the three are aligned are called **spring tides**. When the moon and the sun are at right angles with Earth, their effects on ocean waters tend

to cancel out. This time, the tides are moderately high and moderately low. They are called **neap tides**.

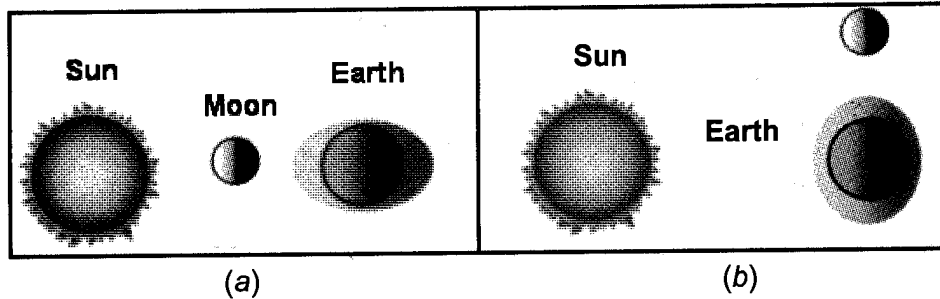


Figure 9.5 (a) Spring tide and (b) Neap tide

Q9.14 During the occurrence of tides, why is it that observers on board a sailing ship do not feel this tidal motion?

Water found inside Earth also experiences tides. We may not feel them but instruments do detect regular tidal motions.

#### Home Activity

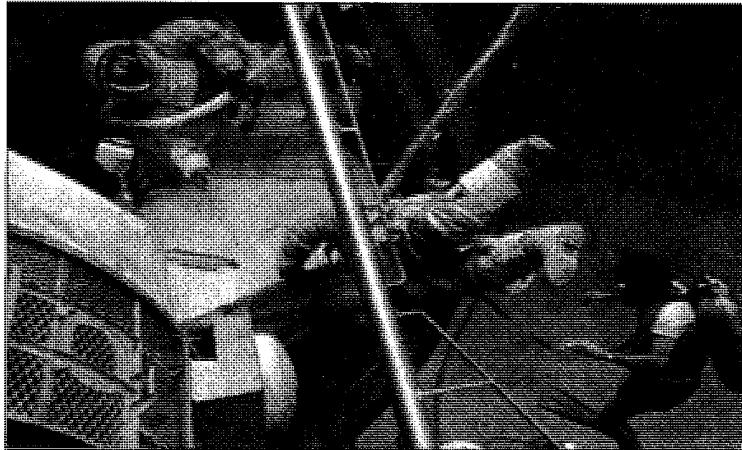
There is a popular notion that some people show unusual behavior during full moon; hence they are called lunatics. Interview some adults in your community about their observations on these. Compare their explanations with those given by doctors. Who is more credible? Explain your choice.

## Lesson 9.5 Manned and Unmanned Space Travel

Long before astronauts and cosmonauts made successful landings on the moon, unmanned spacecrafts had been sent to space to take a closer look at the moon's surface. These spacecrafts carried instruments that have been programmed to gather data and send these data back to Earth. The data helped thousands of scientists, engineers, technicians, and other people of different professions prepare for the first grand step on the moon.

Long before the actual flight, astronauts undergo very rigid training. They practice the techniques of launching and landing and how to live in

their capsules while in space. To perform their many tasks there, they experience the effects of weightlessness. They learn to maneuver their spacecraft, to “walk” in space, outside (Figure 9.6) and inside the spacecraft. They are trained how to bring their spacecrafts together to form an even larger spacecraft, which carries all the essential equipment needed for more accurate observations.



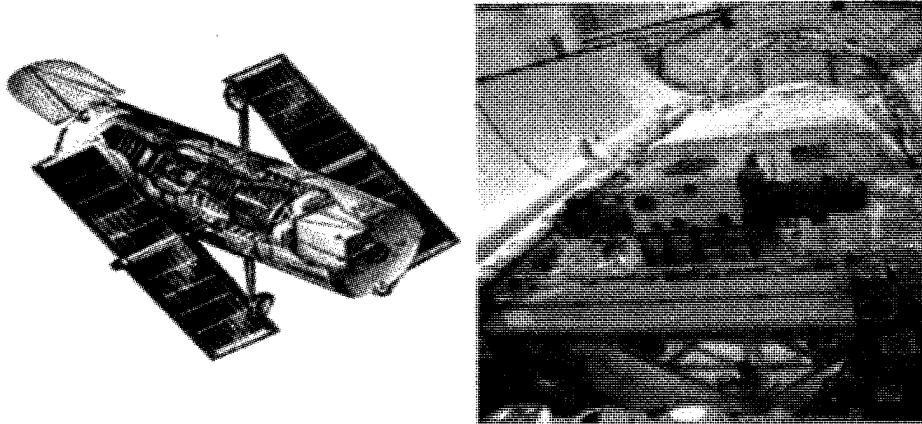
*Figure 9.6 Astronauts (Source:<http://history.nasa.gov/EP-107/>)*

The idea of building a magnificent observatory on the moon has been proposed. The moon may even become a future space station. Due to its proximity to Earth, it would be logical to use the moon as a stopover station for travel to other parts of the solar system. These days, it may even be possible for astronauts to set out to Mars from the moon. Launching rockets from the moon will be a lot easier due to its lower gravity. Why are these possible?

There are no gases on the moon to block the electromagnetic radiation that will relay information about the universe back to Earth. On Earth, we observe light from the stars twinkling through our telescopes. This light which passes through Earth’s atmosphere distorts images. Once telescopes have been set on the moon, the images seen from the lens will not be distorted. Seen directly from the moon, the stars would shine even brighter, clearer, and steadier than when we try to view them from Earth.

A lunar space station may be a bit too far into the future due to the immense technological requirements and the cost of transporting materials to and from the moon. However, putting an artificial satellite beyond Earth’s atmosphere to serve as platform for a telescope to observe the heavenly bodies has been a reality since 1990. The Hubble Space Telescope orbits 600 km above Earth, working around the clock to unlock the secrets of the universe. It uses state-of-the-art instruments to provide stunning views of the universe that cannot be made using ground-based telescopes.

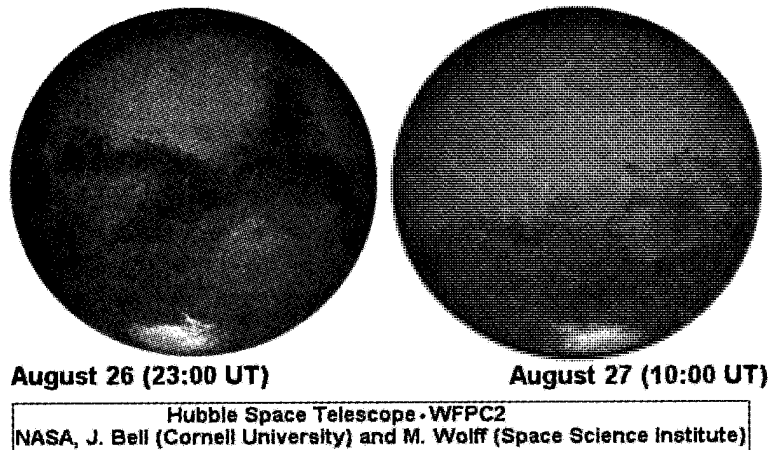




*Figure 9.7 The Hubble Space Telescope*

The Hubble telescope obtained the best view of Mars ever obtained from Earth. Frosty white water ice clouds and swirling orange dust storms above a vivid rusty landscape reveal Mars as a dynamic planet.

**2003 Closest Mars Encounter**



*Figure 9.8. These features of Mars were seen through the Hubble telescope*

The Hubble telescope also provided spectacular views of Comet Shoemaker-Levy 9's collision with Jupiter, the first detailed images of Pluto, now considered a dwarf planet, and its satellite Charon, and new understanding of the atmospheres of Uranus and Neptune.

At present, a big artificial satellite called International Space Station (ISS) is near completion. This cooperative undertaking by 16 nations is the biggest and most complex scientific project in history.

The ISS orbits at about 366 km above Earth. Its orbit has an inclination of 51.6° allowing it to be easily reached by the launched vehicles from the participating countries. This allows it to view up to 85% of the

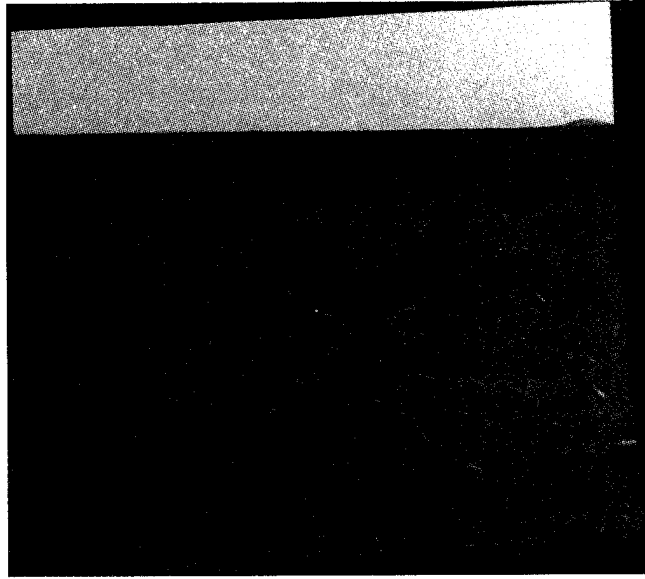
globe. Why is so much time and money being spent on the space station?

The space station provides unique conditions that are impossible to replicate here on Earth. Among the research activities that can be done on the space station are as follows:

- Growth of purer protein crystals: Protein crystals can be grown and studied in space to explore possible treatments for cancer, emphysema, and other immune system disorders.
- Tissue culture under low gravity condition: Low-gravity conditions allow cells to grow undistorted by gravity.
- Effect of low-gravity conditions on humans: Long-term effects of living under low-gravity conditions such as weakening of muscles, loss of bone density, and change in functioning of the heart, arteries, and veins.
- Behavior of flames and fluids: Flames burn differently due to the absence of convection currents.

In 2004, two rovers—Spirit and Opportunity—were sent to Mars to look for evidence in the rocks and soil of watery environments that could support life. Initial analysis of soil samples collected by Spirit revealed some unexpected findings. One such finding is the detection of a mineral called olivine, known to be very sensitive to weathering. The lack of weathering in the sample site could be evidence that the soil particles are composed of fine volcanic material.

Another mineral that could also provide clues about the existence of water on Mars is hematite. This is a shiny grey mineral commonly used for jewelry. Grey hematite is an indicator of the presence of water. Deposits of this mineral are usually found in places where there has been standing water or hot springs. However, it can also form as a result of volcanic activity.



*Figure 9.11 Mars' surface as photographed by the Rover Spirit. Credit: NASA/JPL/Cornell*

Large concentrations of hematite were found by the Mars Global Surveyor in 1998 near the equator. The Opportunity rover is intended to land in an area rich with hematite to investigate the origin of the deposits.

Other minerals found with the hematite could also provide clues. The presence of clays and carbonate minerals would mean that there was once water in the area. Olivine and pyroxene would be suggestive of volcanic activity.

Q9.15 If you are selected to be one of the space travelers to fly to outer space with a load limit of 1,000 kg and you are to leave within a week, what things would you bring with you? Why? Upon reaching your destination, what will you do? What important messages would you relay to people back home?

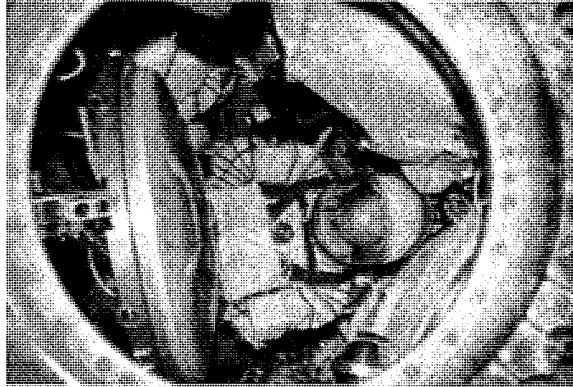
## **Lesson 9.6 How Humans Survive in Space**

In 1957, the world's first artificial satellite was launched into orbit by the Soviet Union. Less than four months later, the Americans launched the next spaceships with a crew of people maneuvering them.

When a human being is on board a spaceship, we are adding a complex and delicate living organism to it. We can alter the nonliving mechanisms in a space vehicle to fit the conditions of space. But we have to consider a human being as he or she is, and alter the conditions in the surroundings to fit his or her body needs.

A human being cannot be redesigned. Humans must breathe air to obtain about 5 000 litres of oxygen each day. They have to preserve a body temperature of 37 °C which can be adequately maintained only if the temperature around is neither too high nor too low.

The human body is best fit to survive at or near the sea level pressure which is about 10 N/cm<sup>2</sup> of his or her body. If an astronaut is suddenly “thrust” into space unprotected and subjected to the zero pressure in space, the pressure inside blood vessels and lungs would make an astronaut burst like a balloon.



*Figure 9.10 An astronaut inside a spaceship*

To survive and continue functioning normally, an astronaut’s body has to be enclosed or wrapped in a fire-resistant suit equipped to preserve normal body pressure. He or she is also attached by cables to life-supporting mechanisms that would provide more adequate supply of oxygen, food, and precious water. Wastes from his or her skin, kidneys, bowels, and lungs must be disposed of.

On Earth, humans can survive the normal dose of radiations from the sun and other bodies in space which filter through Earth’s atmosphere. However, in space way above the atmosphere, humans must be protected from powerful cosmic rays and intense ultraviolet radiation.

**Q9.16** What harmful effects are due to exposure to ultraviolet radiation?

Our body is accustomed to the rhythm of day and night, to working and constant moving around, to eating and making necessary changes in the environment. In space, however, an astronaut faces the possibility of suffering from fatigue because of constant confinement inside the spacecraft. Experiments on Earth teach us that fatigue can readily result in a decreased sense of perception, indecision, and impaired judgment. While in space, astronauts will also experience the problem of “weightlessness.”

In spite of these inconveniences, the presence of humans in a spaceship increases the range of accomplishments and chances of success of space missions beyond doubt.

**Q9.17** Can a machine match human intelligence, courage, perseverance, and creativity? What are some things that humans can do which machines cannot?

How is an astronaut supported and protected in space? Although the precise methods vary with the nature of the vehicle used and the duration of the trip, some guiding principles can be stated. Some of these are:

- An astronaut is encased in an air-tight vehicle that protects him or her from the vacuum of outer space in which he or she travels.
- Pressure inside the cabin need not be as high as that on Earth, which is about  $1 \text{ N/cm}^2$ . By reducing the pressure to about  $0.5$  to  $0.7 \text{ N/cm}^2$ , the weight of the air that the spaceship carries with it is reduced. This minimizes the ship's tendency to burst as it is thrust into space. Reduction of air pressure in pressurized jet planes is done for the same reason.
- To protect the astronaut against the consequence of a possible break in the cabin wall which would affect the pressure inside, he or she is fitted with a loose air-tight suit which automatically preserves the pressure needed around the body.
- Oxygen must be carried along to provide the astronaut regular and uniform concentration of his or her usual dose of air. Several methods of supplying much-needed oxygen are being used. One is to carry the total oxygen supply in containers in either gaseous or liquid state. A second method is to obtain oxygen from oxygen compounds. A third is to bring green plants along, such as algae, to produce oxygen. A fourth method would be to split the oxygen away from the carbon dioxide breathed out by the astronaut.
- Waste gases, such as carbon dioxide and water vapor, are removed from the cabin's atmosphere. Lithium hydroxide is a light-weight chemical which can remove carbon dioxide. Water vapor exhaled out can be removed by condensation on a cold surface. The condensed water can then be recycled as drinking water.
- Equipment for conditioning the air to the right temperature is needed. In the project Apollo, the evaporation of water from the spaceship into the vacuum of space provided the needed cooling. In longer travel, a mechanical refrigeration system is used.

As a rocket ship picks up speed on its way up, the astronaut feels heavier and heavier. This is similar to the experience we have when we are on an elevator going up. We feel ourselves getting heavier. Or when we are riding in a bus and the driver steps on the gas, we are pushed hard against our seat. When a rocket ship accelerates, the astronaut feels the extra push. A rocket leaving the launch pad must have a push of about twice that of the pull of Earth's gravity.

Extra weight is also experienced when a spaceship slows down. This may be compared to the experience of pushing down with one's feet and

bracing with one's hands against the dashboard when the driver steps hard on the brakes.

The "increased weight" experience results not from speed itself but from the change in speed. When we travel in a jet at about 200 km/h, we often feel that we are motionless, unless we look at passing clouds and the landscape. It is when the plane takes off, or finally lands, and slows down that we get to feel the push.

When the spaceship ceases to accelerate, that is, when the rockets are not blasting and the ship is simply cruising along at constant speed, the astronaut experiences weightlessness. This happens when he or she is in orbit around Earth or for much of the time when he or she is traveling in space to the moon.

Prolonged weightlessness is a new experience for humans. Weightlessness occurs when the effects of an object's motion (like being blasted into space) cancels out the pull of gravity. The astronauts on board Apollo 11 experienced the same sensation during their two days stay on the moon. They enjoyed "floating" in space and walking in slow motion.



*Figure 9.11 Weightlessness*

There are no strict orders or restrictions regarding the type or choice of food supplies to be taken on board the spacecraft. Common sense tells us that provisions should neither be crumbly nor in flaked form. In the absence of gravity, it would not be long before crumbs float around inside the capsule and one would need a net to catch and contain them. In the same light, it would not be convenient and wise to attempt to eat in the same manner that one normally does on Earth. For obvious reasons, one cannot use utensils. All these would float in mid-air. Food is best taken in directly into the mouth either in capsule form or squeezed in from

tubes. Drinks would be sipped using straws (air pressure) as there is no gravity that would force the liquids out of the cup.

Space exploration is no longer a fantasy. Humans have already placed hundreds of satellites into orbit around Earth. Experiments have been carried out in space, including the ability of spiders to spin webs, the life activities of mice, dogs, and monkeys, and of course, humans. Humans have explored the moon and remote-controlled robots have explored Mars. Details for Venus probes and permanent moon bases have been worked out and men are now building the spacecrafts for these exploits. Later, space residents will follow suit. Flights beyond our solar system, perhaps to other worlds in space, will be possible in the future.

Space flight is inherently dangerous and the NASA crew member is familiar with the risks involved. On January 28, 1986, America was shocked by the destruction of the space shuttle Challenger, and the death of its seven crew members which included a woman teacher. Burning rocket propellant had burned one of the primary O-ring seals in one of the booster rockets. Nevertheless, humans continue to take great risks in the hope of making breakthroughs for progress.

## Lesson 9.7 Watching the Night Sky

The study of the sky dates as far back as 4000 B.C. Ancient Egyptians and Chinese already had some knowledge about the motions of the sun, moon, and planets. The Babylonians also observed the sun, moon, planets, and stars for they believed that these heavenly bodies were gods. Babylonian priests further believed they could predict from the position of heavenly bodies future events on Earth. This is what we now call astrology. **Astrology** studies the position of planets and stars in the sky in the belief that these could influence the affairs and fate of humans. This assumption, however, has yet to be proven scientifically and is more popularly known as horoscope.

Q9.18 Are you fond of reading horoscopes? Do you believe in it or not?

There is a need to distinguish the study of stars to predict one's future (i.e., horoscope based on the zodiac sign you were born in cited earlier) from the formal study or branch of science that deals with the study of such heavenly bodies. **Astronomy** refers to the science that treats or studies celestial bodies, giving emphasis to their positions, magnitudes, motions, distances, constitution or physical makeup, physical conditions, mutual relations, history and destiny, and their effects on life forms on Earth.

Stars can help the traveler locate positions and directions whether he or she travels by air or by water. The stars are not equally spread out in

outer space. Many of them appear to be arranged in groups or patterns. These apparent patterns of stars long imagined outlining the shapes of objects or beings are called **constellations**.

To investigate some constellations in the night sky, you can start with a simplified star map. You can do Activities 9.3 and 9.4 at home or during your recess.

### **Activity 9.3 Making a Star Map**

#### **Materials**

1 large-size white cartolina      ruler      pencil

#### **Procedure**

1. Study Figure 9.12 in the next page.
2. On a clear night, look for the seven bright stars of the Big Dipper. You may rotate Figure 9.13 until the Big Dipper appears to be in the same position on the figure as in the sky.
3. Locate the pointers—two stars at the edge of the cup of the Big Dipper. Trace an imaginary straight line through the pointers and extend this to about 5 times the distance between the pointers. At the end of this line, you will see Polaris, the North Star. It is at the end of the Little Dipper.
4. Locate a line of stars winding between the Big and the Little Dippers. The line bends around a little from the Little Dipper. At the end of the line are four stars forming the head of the dragon. This is Draco.
5. Imagine a straight line from the tip of the handle of the Big Dipper through the North Star and extend it farther. It will point to the W-shaped constellation. This is Cassiopeia. Cassiopeia and the Big Dipper are found on opposite sides of the North Star.
6. Extend the line from the pointer stars to Polaris, the line will reach the constellation Cepheus. It is near Cassiopeia. It is shaped like a church tower.
7. Make a list of other constellations that you see aside from the polar constellations. Refer to Figure 9.12.



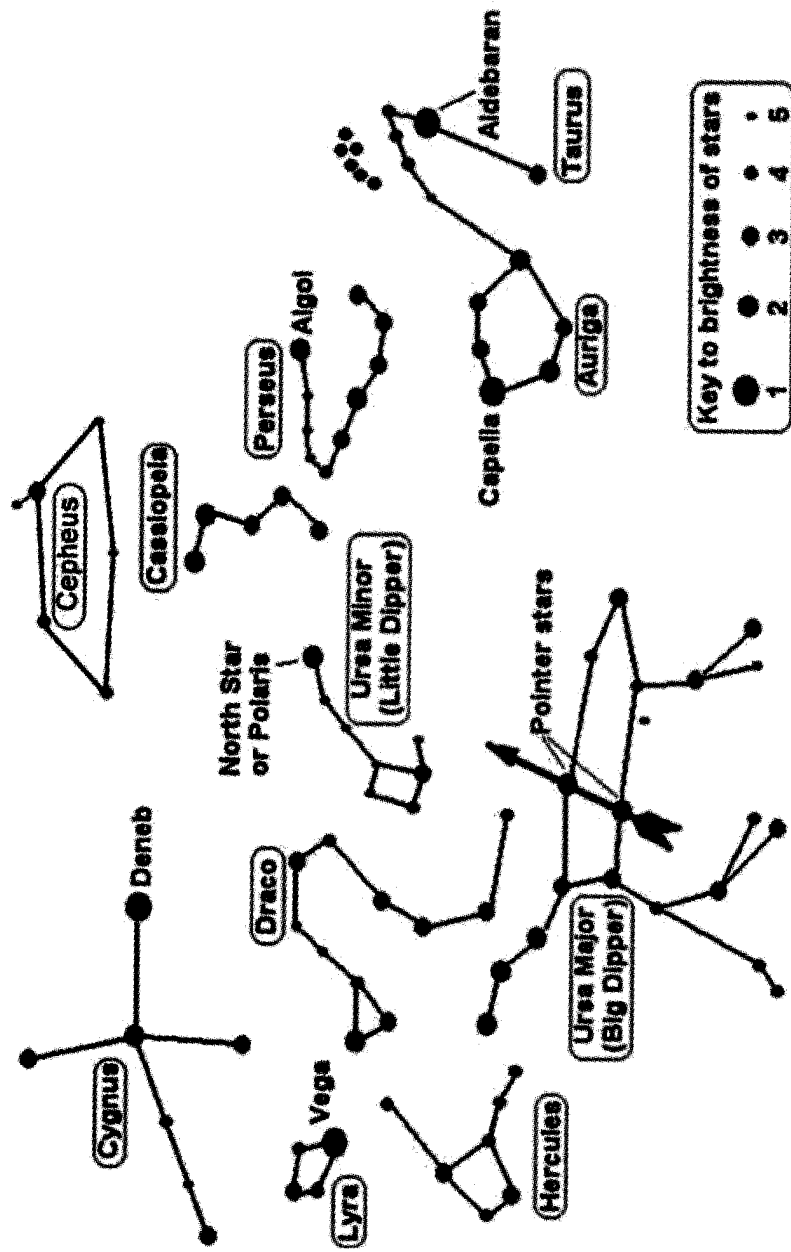


Figure 9.12 Common constellations near Polaris

Have you been to a planetarium? There is one at Rizal Park in Manila and in the Science Garden at Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) in Quezon City. If you should have the chance to be near these places, make arrangements to visit the planetarium. For your home activity, build a constellarium. The following activity will show you how to make one.

### **Activity 9.4 Making a Constellarium**

#### **Materials**

shoe box with cover	blade or scissors	cardboard or
aluminum foil	small nail	styrofoam or
sheets of bond paper	pencil	old newspapers
pictures of different constellations	tape	
	pin	

#### **Procedure**

1. Measure 1.5 cm at one small end of the shoe box.
2. At the opposite end, cut a 1 cm hole at the center. This will be the viewing hole.
3. Draw several constellations on a sheet of bond paper. Refer to the star map.
4. Cut several pieces of tin foil 1 cm bigger on all sides than the size of the window on the shoe box.
5. Get one cut tin foil and place it under one constellation drawn on the bond paper. Put the foil and paper on top of a cardboard or a styrofoam or folded newspapers.
6. Transfer the drawing of the constellation on the tin foil by pricking the stars drawn on the paper with a pen (for smaller stars) and a nail (for bigger stars). Label the foil with the name of the constellation.
7. Repeat the above procedure for each constellation you trace on a tin foil.
8. Tape one foil inside the window and cover the shoe box.
9. Hold your constellarium against a light source and look through the viewing hole.
10. You can also place all the polar constellations on one tin foil for viewing through the constellarium.

Most constellations are visible only at certain times of the year. This means that to find Orion and other constellations you must use a star map that is right for that month. If you want to identify other stars and constellations, ask your teacher for instructions in using the star map.

### Home Activity

Observe the night sky on a clear night. Notice that stars have different colors. Some are red, others are blue, while still others are white. What do these colors mean? You must have experienced placing one end of a pin in a candle flame. You observe that the metal turns red, then yellow, then white as it gets hotter. Star colors and temperature are related in the same way.

Q9.19 Which are hotter, yellow stars or red stars? White stars or yellow stars? Blue stars or white stars?

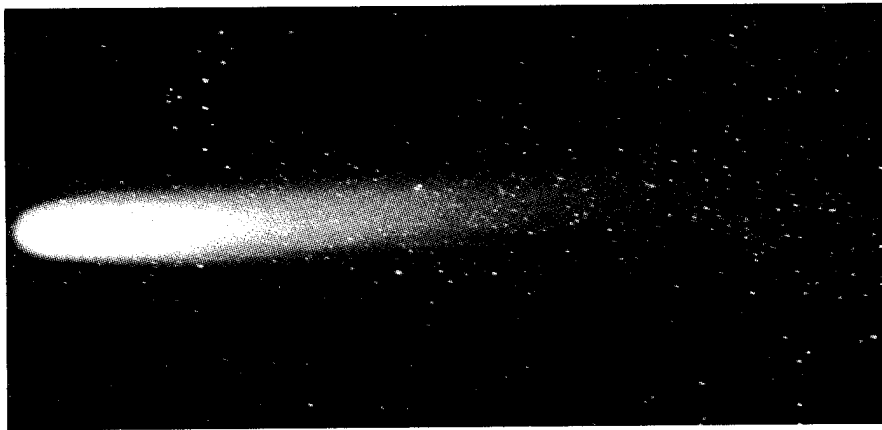
Q9.20 Is the sun the hottest star? Why or why not?

## Lesson 9.8 Asteroids, Meteors, and Comets

This time imagine yourself as a visitor from another solar system, entering our solar system through a spacecraft. What will you see?

- The planets revolving around the sun
- The moon, Earth's natural satellite
- The moons of other planets
- A swarm of tiny planetoids between the orbits of Mars and Jupiter. Some 150 of them have been photographed from Earth. There might be 50 000 asteroids in this space.
- Bits of stones and pieces of metal moving through space beyond the solar system. Though harmless, your spacecraft may collide with these meteoroids. When a meteoroid plunges into the atmosphere of Earth, friction caused by the rubbing of matter with air particles in the atmosphere, heats up the meteoroid until it glows. It is then called a **meteor** and appears as a shooting or falling star in the night sky, making a streak of light as it disintegrates in the upper atmosphere.

- Bigger chunks of metal or stone that come hurling through space may reach the surface of Earth. **Meteorites**, as they are called, are meteoroids that have survived burning up in Earth's atmosphere and have reached the ground.
- Possibly a **comet** which is a collection of dust-size particles of solidified gases and water seen from Earth as a spectacle of a luminous head and a thin veil. This may be the most beautiful heavenly body you may have observed. It does not give off its own light and it becomes visible only as it approaches the sun and reflects light. These comets follow a regular path as they travel around the sun. A number of comets are known to have long and narrow orbits that periodically cross the solar system. The famous **Halley's Comet** was seen in 1910 and again came close to the Earth in 1986. It will come again in 2062.



*Figure 9.14 Halley's comet*

Knowing the properties of these heavenly bodies, answer the questions below.

- Q9.21 Why is it dangerous for a spacecraft to collide with asteroids in space?
- Q9.22 Where do you expect to find a) meteoroids; b) meteors; and c) meteorites?
- Q9.23 In what way are comets and asteroids similar? How are they different?
- Q9.24 In what way is a comet like a planet? How are they different?
- Q9.25 How many years is the interval between each reappearance of Halley's Comet? Why does it take this long for Halley's Comet to be seen again from Earth?
- Q9.26 Are the brightest comets those closest to the sun or those farthest from the sun? Why?

## SUMMARY

History records how new ideas about the universe came about with the logical reasoning of Copernicus, Galileo, and others. Earth is not the center of the universe, but rather it is Earth, together with other planets, that revolve around the sun. The revolution of the Earth around the sun at a given tilt causes change in seasons in various places, while its rotation on its axis causes the alternating night and day. The Philippines' seasons are mainly due to the amount of sunlight it receives because it is located near the equator.

The solar system is mainly empty space. The distance of the planets from the sun affects the surface features of the planets.

Earth's moon has been the focus of study because it affects us. A solar eclipse happens when the moon blocks Earth's view of the sun, while a lunar eclipse occurs when Earth's shadow blocks the moon. Due to the nearness of the moon, its gravitational attraction causes a periodic rising of water level called tides. Exploration of the moon has resulted in greater knowledge about the actual conditions of outer space.

Several space stations are orbiting Earth. These stations are basically used for research that will have benefits to humankind. Some space explorations are manned, others are not. These activities are not only expensive but risky. Astronauts are protected to cope with weightlessness, reduced pressure, and the presence of high-intensity radiations. Air, water, and food supply are designed to be compact, conveniently stored, and adequate for the trip.

Besides our interest in our solar system, we are also interested about constellations—patterns formed by stars relative to their positions in the sky—to tell time, weather, seasons, and find directions since ancient times. The stars appear to have different intensities and colors due to their different distances from Earth, their varying temperatures, and compositions. Asteroids, meteors, and comets are the other bodies in space that have various interesting characteristics. Studying them resulted in the discovery of related applications and solutions to some of our problems on Earth.

## SELF-TEST

### I. Multiple-Choice Items

Choose the letter of the correct answer.

1. All planets in the solar system
  - a. revolve around the Earth.
  - b. have one or more satellites.
  - c. rotate at the same speed.
  - d. can be seen because they reflect sunlight to Earth.

2. If the following small bodies are orbiting around the sun, which of them will most likely become a comet?
  - a. a hot rocky body
  - b. a hot metallic body
  - c. a cold icy body
  - d. a cold rocky body
3. If Jupiter is much larger than Earth, why does it have a lower density?
  - a. Because Jupiter is rotating faster than Earth
  - b. Because Earth is closer to the sun than Jupiter
  - c. Because Jupiter is a gaseous planet while Earth is rocky
  - d. Because Earth has a thinner atmosphere than Jupiter
4. What explains why the sun is the only star from which Earth receives much heat and light?
  - a. The sun is much closer to Earth than the other stars.
  - b. The sun is much bigger than the other stars in the universe.
  - c. The sun is much hotter than the other stars in the universe.
  - d. The sun is the only star that gives its own heat and light.
5. What conditions on a planet would make it very hot?
  - a. hot and with no atmosphere
  - b. thick carbon dioxide clouds
  - c. sandy and cratered surface
  - d. plant-covered surface
6. What is the cause of Earth's seasons?
  - a. Earth's elliptical orbit and varying speed of revolution
  - b. Earth's greater distance from the sun during winter than summer
  - c. Inclination of Earth's axis of rotation to the plane of its orbit and revolution around the sun
  - d. Variation in the amount of energy given off by the sun
7. A boy standing in an open field on a bright sunny day casts a long shadow pointing east. What time of the day is it?
  - a. late afternoon
  - b. early afternoon
  - c. high noon
  - d. early morning
8. How do we know that comets belong to the solar system?
  - a. Comets revolve around the sun.
  - b. Comets visit the Earth periodically.
  - c. Comets are broken parts of a planet.
  - d. Comets follow circular orbits as planets do.

9. Which of the following conditions can cause an eclipse of the moon?
- When the moon passes between the sun and Earth
  - When the moon passes through the shadow of Earth
  - When the moon is at first- and third-quarter phases
  - When the moon is halfway on its orbit around the Earth
10. How does a comet differ from a meteor?
- A comet revolves around the sun while a meteor does not.
  - A comet has an elliptical orbit while a meteor has a circular orbit.
  - A comet develops a tail of gas and dust while a meteor has no tail.
  - A comet reaches outer space while a meteor does not go beyond Jupiter's orbit.
11. How long is a day on the moon?
- 12 hours
  - 24 hours
  - 27  $\frac{1}{3}$  days
  - 29  $\frac{1}{2}$  days

For questions 12 to 15, refer to the table below.

Planet	Density (g/cm <sup>3</sup> )	Diameter	Gravity	Rotation	Revolution
A	5.52	12 000 km	1	24 h	1 y
B	3.84	6 800 km	2 X A*	24.5 h	1.88 y
C	1.31	143 000 km	5 X A	9 h	12 y
D	0.70	121 000 km	3 X A	10 h	30 y

\* Gravity of A = 1; 2 X A means the gravity of Planet B is two times stronger than that of Planet A.

12. Which planet would be farthest from the sun?
- A
  - B
  - C
  - D
13. Which planet would have the shortest day?
- A
  - B
  - C
  - D
14. Which planet would have a more flattened shape?
- A
  - B
  - C
  - D
15. If an astronaut can go to these planets, where will he be heaviest?
- A
  - B
  - C
  - D

## II. Matching Type

A. Match the features of the planets in Column I with the correct names of the planets in Column II.

### Column I

1. largest planet
2. most cratered planet
3. planet with rings of water ice
4. planet with ice caps

### Column II

- a. Mercury
- b. Venus
- c. Earth
- d. Mars
- e. Jupiter
- f. Saturn
- g. Uranus
- h. Neptune
- i. Biyo

B. Match the descriptive phrases in Column I with the correct names or terms in Column II.

### Column I

1. motion of planets around the sun
2. spacecraft that landed on moon
3. shape of planet's orbit
4. astronaut who first stepped on the moon
5. the only satellite of the earth

### Column II

- a. ellipse
- b. Collins
- c. moon
- d. revolution
- e. Apollo 11
- f. Armstrong
- g. rotation