10

Science

Learner's Material
Unit 1

This book was collaboratively developed and reviewed by educators from public and private schools, colleges, and/or universities. We encourage teachers and other education stakeholders to email their feedback, comments, and recommendations to the Department of Education at action@deped.gov.ph.

We value your feedback and recommendations.

Department of Education
Republic of the Philippines

Science – Grade 10
Learner's Material
First Edition 2015

Published by the Department of Education
Secretary: Br. Armin A. Luistro FSC
Undersecretary: Dina S. Ocampo, PhD

Development Team of the Learner's Material

Authors: Herma D. Acosta, Liza A. Alvarez, Dave G. Angeles, Ruby D. Arre, Ma. Pilar P. Carmona, Aurelia S. Garcia, Arlen Gatpo, Judith F. Marcaida, Ma. Regaele A. Olarte, Marivic S. Rosales, Nilo G. Salazar
Reviewers: Eligio C. Obille Jr., Marlene B. Ferido, Ma. Helen DH Catalan, Vic Marie Camacho, Lilia M. Rabago, Cerilina M. Maramag
Illustrators: Joseph V. Bales, Ramon C. Gatpo, Regaele A. Olarte, Marivic S. Rosales, Ruel C. Quindoy, Antonio I. Basilla, Jose Leo Vic O. Albaño
DepEd Specialists: Joseph R. Jacob, Maria Amparo R. Ventura
Photo Credits: Herma D. Acosta, Dave G. Angeles, Liza A. Alvarez, Ruby D. Arre, Aurelia S. Garcia, Judith F. Marcaida, Regaele A. Olarte, Jane Chavarria, Nilo G. Salazar
Layout Artists: Matthew Daniel V. Leysa and Mary Grace Ann G. Cadisal

Printed in the Philippines by REX Book Store, Inc.
Department of Education-Instructional Materials Council Secretariat (DepEd-IMCS)

Office Address:	5th Floor Mabini Building, DepEd Complex Meralco Avenue, Pasig City Philippines 1600
Telefax:	(02) 634-1054, 634-1072
E-mail Address:	imcsetd@yahoo.com

TABLE OF CONTENTS

UNIT 1

Earth and Space

Unit 1: Earth and Space

Overview

In your Grade 9 Science, part of your lessons was about volcanoes. You have learned about the position of the Philippines in the Ring of Fire and its relationship to the presence of active and inactive volcanoes in our country.

In this quarter, the topics will focus solely on a theory that explains the existence of volcanoes and other geologic features. You have two modules to understand this theory better.

In the first module, you will use some of your science skills such as graphing, measuring, analyzing and interpreting data, and inferring for you to attain the desired outcomes.

What are the outcomes that are expected from you? First, you should identify the types of boundaries created because of lithospheric movements. Secondly, you must relate the movement of Earth's lithosphere to the occurrence of different geologic changes. And finally, you will explain the processes that are taking place along the boundaries.

In the second module, you will perform an activity that will allow you to probe the Earth's interior by analyzing the behavior of seismic waves (Primary and Secondary waves). You will also have an opportunity to simulate one of the properties of the materials present in the mantle.

Lastly, included in the module, and the most important part is the series of activities that will give you an idea about the driving mechanism behind the motion of Earth's lithosphere.

Unit 1
MODULE
1

PLATE TECTONICS

I. Introduction

Our country is blessed with so many land features such as mountains and volcanoes. These features can be sources of different minerals or can be used for agricultural purposes. For example, we have the majestic and world renowned Mayon Volcano. Because of its activity, it produces fertile slopes and plains which are used by the locals to grow their crops. Also, found in the northeastern coast of Luzon, we have the Sierra Madre mountain range which is home to many endemic species of flora and fauna.

Have you ever wondered why our country is endowed with these kind of geologic features? Well, if your answer is YES, then this module will help you find the answer to your question.

In this module, we will study thoroughly the framework that will enable us to understand how and why several features of the Earth continuously change. This theory is what we call "Plate Tectonics."

This describes the events within the Earth that give rise to mountain ranges, volcanoes, earthquake belts, and other features of the Earth's surface.

At the end of Module 1, you are expected to answer the key question below:

> What is the relationship among the locations of volcanoes, earthquake epicenters, and mountain ranges?

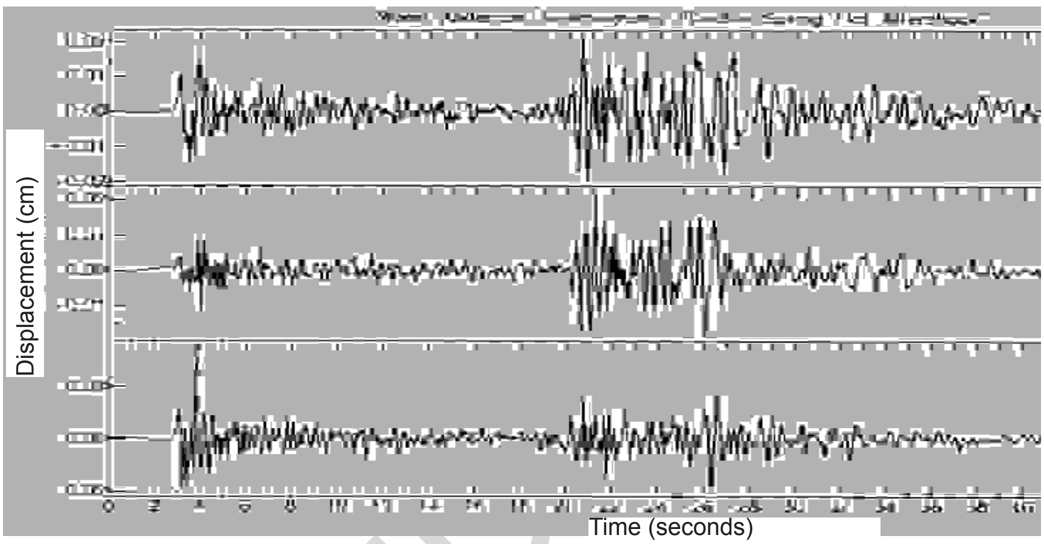
II. Learning Competencies/Objectives

In this module, you should be able to:

1. Describe the distribution of active volcanoes, earthquake epicenters, and major mountain belts.
2. Describe the different types of plate boundaries.
3. Explain the different processes that occur along the plate boundaries.

III. Pre-Assessment

Choose the letter of the correct answer.



For questions 1 and 2, refer to the figure above:

1. You were provided with data showing the arrival time of the P and S-waves recorded from three seismic stations. Which of these can you possibly determine?
   a. the damage at the focus
   b. the distance to the earthquake
   c. the intensity of the earthquake
   d. the location of the epicenter

2. From the seismogram, the distance to the epicenter can be determined by measuring
   a. the arrival time of surface wave
   b. the difference in the arrival times of the P and S-waves
   c. the ratio of the amplitude of the largest P and S-waves
   d. the speed of the surface wave

3. When two tectonic plates collide, the oceanic crust usually subducts beneath the continental crust because it is
   a. denser than continental crust
   b. less dense than continental crust
   c. thicker than continental crust
   d. thinner than continental crust

4. If you visit a place in the Pacific known to be along converging plates, which of these should you **NOT** expect to see?
   a. active volcanoes
   b. mountain ranges
   c. rift valleys
   d. volcanic islands

5. You are an oceanographer and want to map the ocean floor on the east coast of the Philippines. As you do your study, you notice that there is a portion in the ocean floor which is relatively much deeper than the rest. What most likely is that deeper part?
   a. linear sea
   b. oceanic ridge
   c. rift valley
   d. trench

6. What do you expect to find at a mid-ocean ridge?
   a. relatively young rocks
   b. reverse fault
   c. thick accumulation of sediments
   d. very ancient rocks

7. Crustal plate A is moving away from crustal plate B. What is the expected average rate of change in position between A and B?
   a. a few centimeters per year
   b. a few meters per month
   c. a few millimeters per century
   d. a few millimeters per day

8. Which plate boundary is formed between the Philippine plate and the Eurasian plate?
   a. convergent
   b. divergent
   c. reverse fault
   d. transform fault

9. Which of these is **false** about lithosperic plates:
   a. have the same thickness everywhere
   b. include the crust and upper mantle
   c. thickest in the mountain regions
   d. vary in thickness

10. Which of these is **NOT** true about the Philippine islands?
   a. most are part of the Philippine Mobile Belt, except for Palawan, Mindoro, and Zamboanga
   b. formed because of the convergence of the Philippine plate and the Pacific plate
   c. originated geologically in an oceanic-oceanic convergence
   d. some are products of subduction process

IV. Reading Resources and Instructional Activities

What is Plate Tectonics?

Earth's lithosphere consists of layers, the crust and the upper part of the mantle. This part of the module will focus on the outermost layer which is called crust.

The crust is made of a variety of solid rocks like sedimentary, metamorphic, and igneous. It has an average density of 2.8 g/cm^3 and its thickness ranges from 5 to 50 km. The crust is thickest in a part where a relatively young mountain is present and thinnest along the ocean floor.

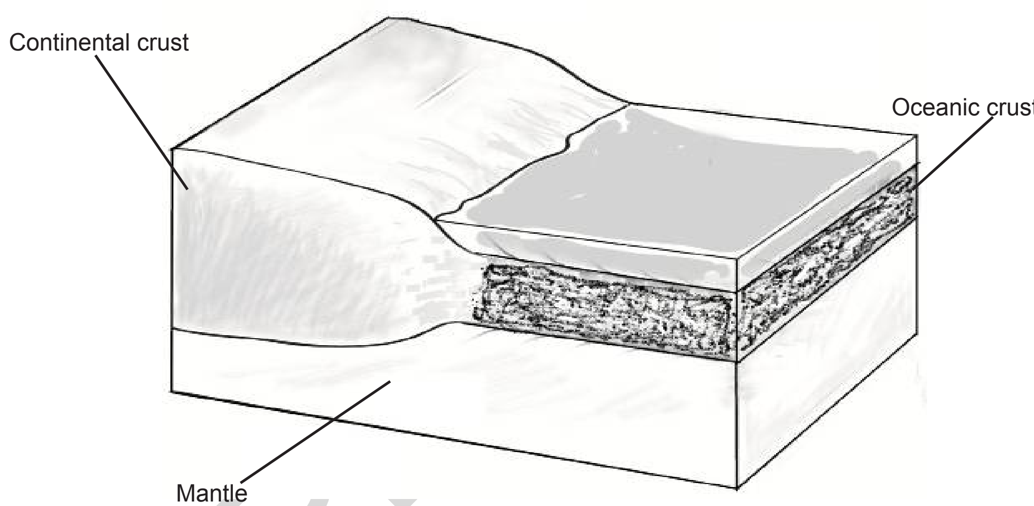
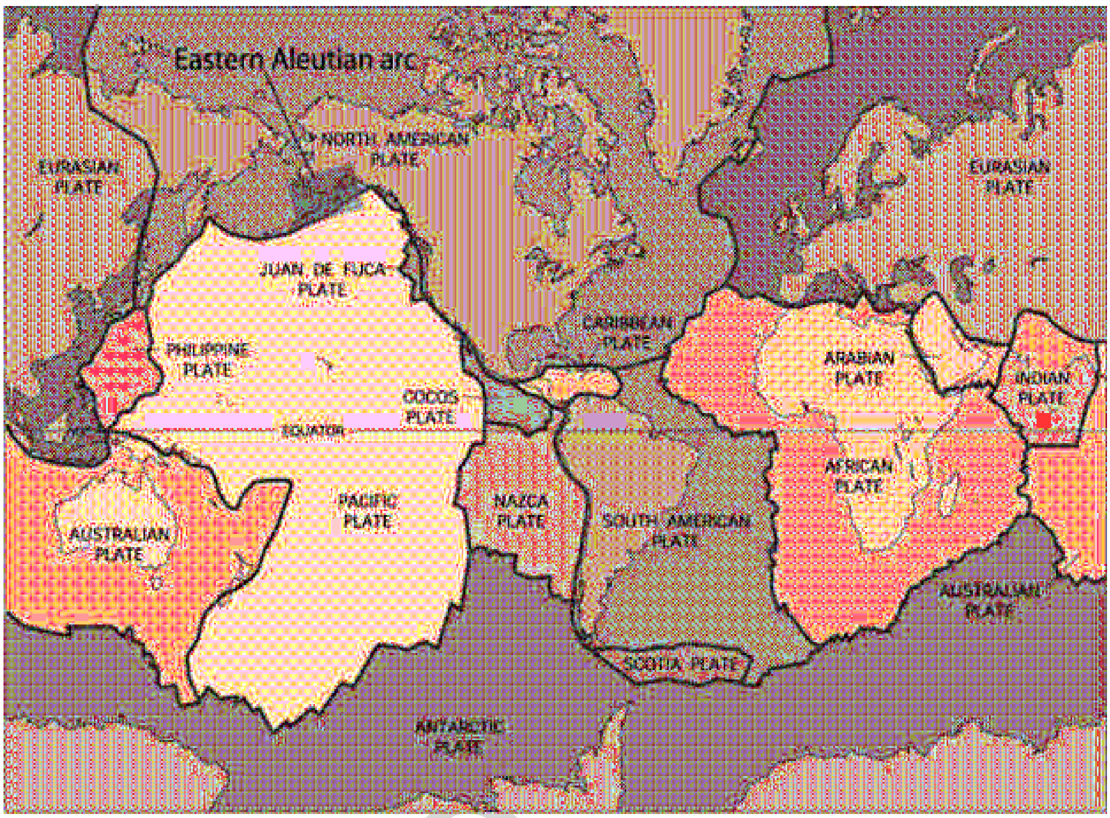


Figure 1. Kinds of crust

You will notice from Figure 1 that there are two kinds of crust: the thicker but less dense continental crust and the oceanic crust which is relatively thinner but denser than continental crust.

According to the plate tectonics model, the entire lithosphere of the Earth is broken into numerous segments called plates (see Figure 2).



http://pubs.usgs.gov
Figure 2. Map of Plate boundaries

As shown in Figure 2, there are seven relatively large plates and a number of smaller ones, including the Philippine plate. The plates move very slowly but constantly, and this movement is called tectonics; thus the theory of moving lithospheric plates is called plate tectonics.

Before we study more about plate tectonics, let's discuss first one of the consequences of moving crustal plates which is crucial in studying plate tectonics: earthquake.

You have learned in your Grade 8 Science that an earthquake releases three types of seismic waves; Primary (P-waves), Secondary (S-waves), and Long surface waves (L-waves). The first two travel into the Earth's interior while the last one on the surface. These waves travel at different velocities; thus, do not arrive at a seismic recording station at the same time. The farther the recording instrument is from the focus, the greater the difference in arrival times of the first P-wave compared to the first S-wave. The difference in the arrival time will tell us the distance of the earthquake's focus from the seismic recording station. However, it does not tell in which direction it came from.

If we have at least three recording stations that can tell how far away from them the earthquake occurred, the epicenter can be determined using the triangulation method. It uses distance information from three seismic stations to locate the earthquake epicenter. On a map, circles are drawn around each seismic station. The radii of the circles are scaled to the estimated distance from the station to the earthquake. The three circles will intersect at one point that locates the earthquake.

The next activity will give you a first-hand experience on how to locate earthquake epicenter.

Activity 1

Find the Center

Objective:

Locate the epicenter of an earthquake using the triangulation method.

Materials:

- hypothetical records of earthquake waves
- Philippine map
- drawing compass and ruler

Procedure:

1. Study the data showing the difference in the arrival time of P-wave and S-wave on three seismic recording stations.

Recording station	Time difference in the arrival time of P-wave and S-wave (seconds)	Distance of epicenter from the station (km)
Batangas	44.8	
Puerto Princesa	32	
Davao	38.4	

2. Compute the distance of the epicenter from each of the stations using this formula:

$$d = \frac{Td}{8 \text{ seconds}} \times 100 \text{ km}$$

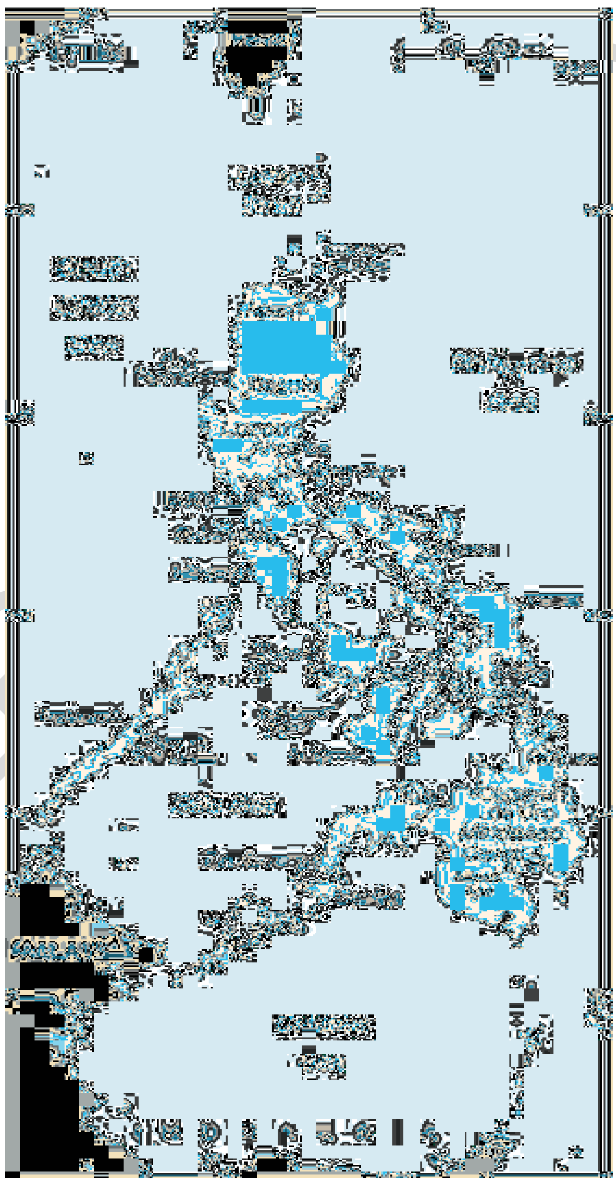
Where: d = distance (km)
Td = time difference in the arrival time of P-wave and S-wave (seconds)

This formula is suited because 8 seconds is the interval between the times of arrival of the P-wave and S-wave at a distance of 100 km.

3. Choose one of the recording stations and measure the computed distance on the map scale (the scale of the map in Figure 3 is 1.5 cm: 200 km). Set your compass for that computed distance.

4. Center your compass on the station you have chosen. Draw a circle.

5. Repeat steps 3 and 4 for the rest of the stations. You should get three circles that intersect or nearly intersect at a point. This intersection is the epicenter.

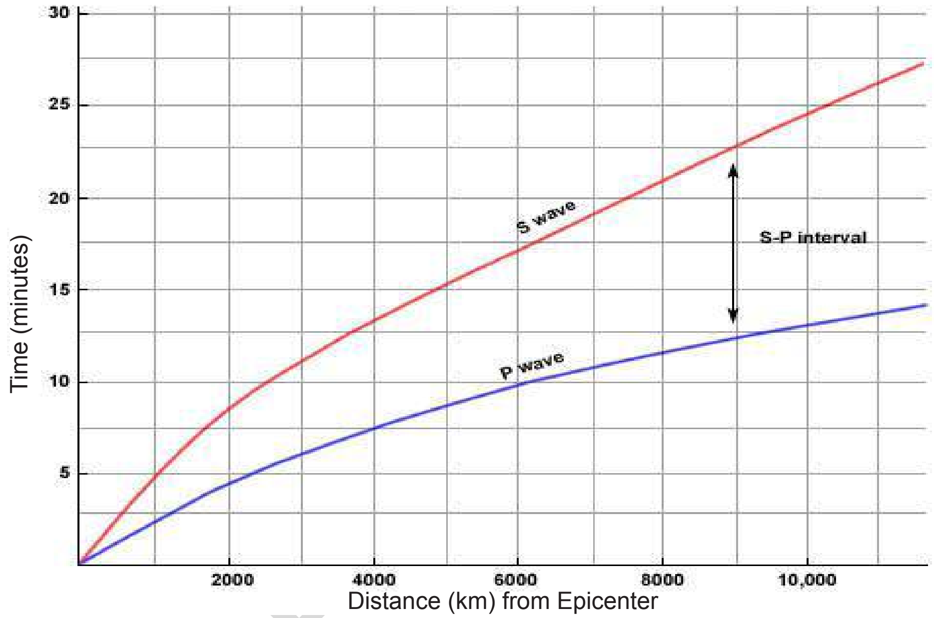


http://earthquake.usgs.gov
Figure 3. Map of the Philippines

Q1. Where is the epicenter of this hypothetical earthquake?

Q2. What difficulty will you encounter if you only have data from two recording stations?

In the previous activity, the hypothetical earthquake happened locally, that is why we use the formula stated in the procedure. But, if the earthquake took place at a far greater distance, seismologists use the distance-time graph similar to the figure below in determining the location of the epicenter.



http://stream2.cma.gov.cn/pub/comet/Environment/TsunamiWarningSystems/comet/tsunami/warningsystem/print.htm

Figure 4. Distance-time graph

The distance-time graph above shows that the S-P interval is about 10 minutes.

Q3. What is the distance of the epicenter from the seismic station?

Q4. What do you think is the importance of determining the epicenter of an earthquake?

Determining the location of earthquake epicenters plays a vital role in laying the foundations of plate tectonics. Let us see how early geologists used the plotted positions of earthquake epicenters throughout the world in conceptualizing crustal movements.

Activity 2

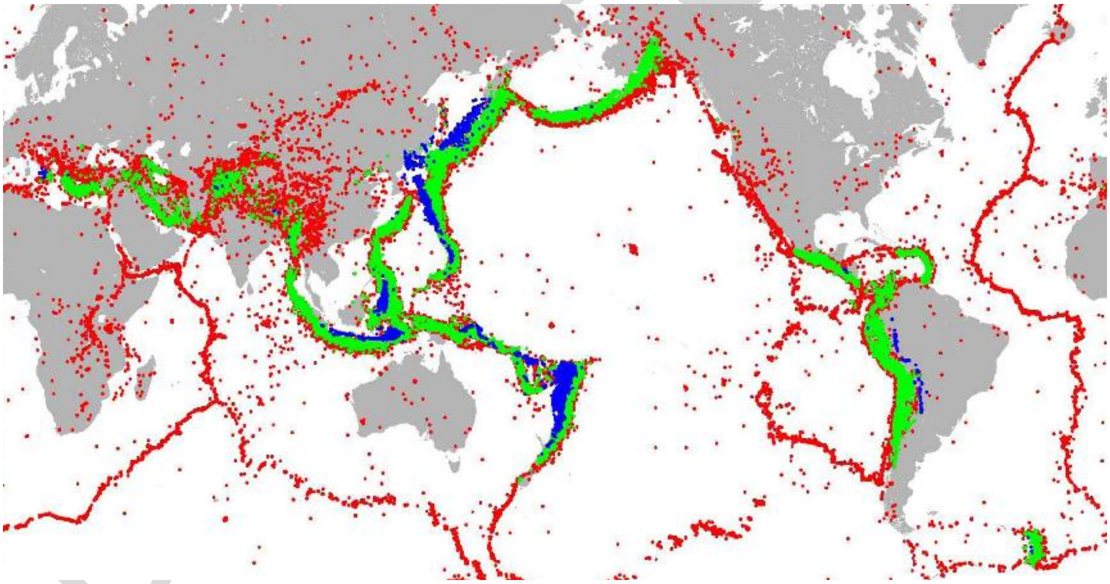
Let's Mark the Boundaries

Objectives:

- Describe the distribution of active volcanoes, earthquake epicenters, and major mountain belts.
- Determine the scientific basis for dividing the Lithospheric plates.

Materials:

- Figure 5: Map of earthquake distribution
- Figure 6: Map of active volcanoes of the world
- Figure 7: Mountain ranges of the world
- 2 pieces plastic sheet used for book cover, same size as a book page
- marking pens (two different colors)



http://marc.fournier.free.free.fr

Figure 5. Map of earthquake distribution (Red, green, and blue dots represent earthquake epicenters)

Procedure:

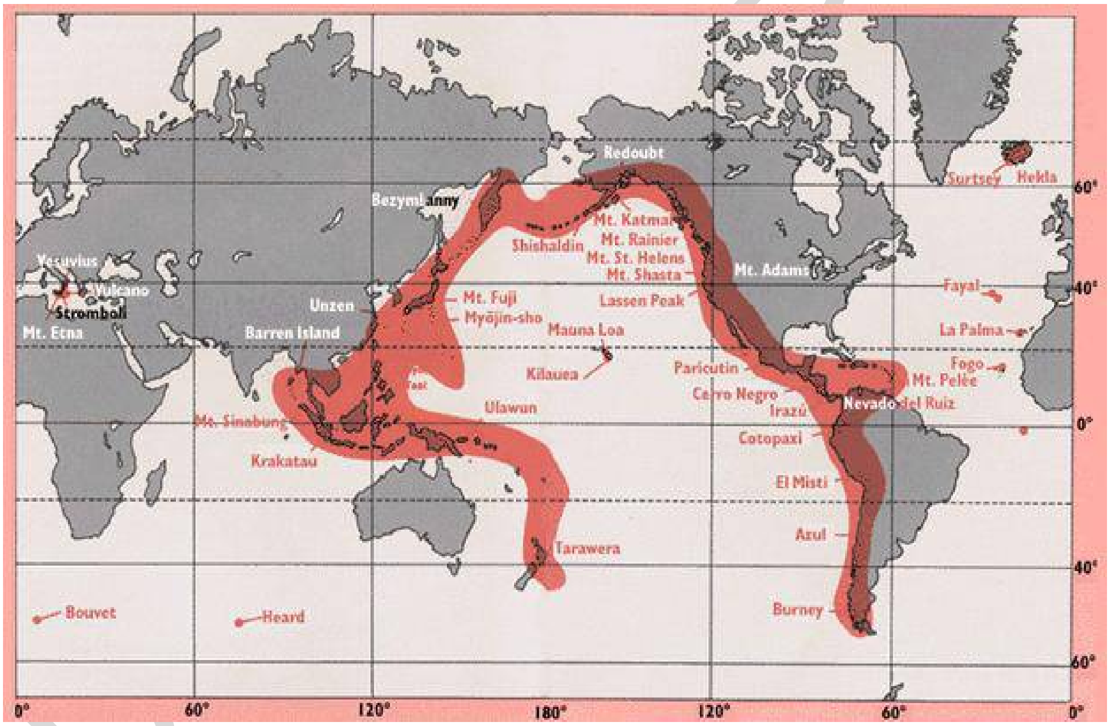
1. Study Figure 5 showing the earthquake distribution around the world. Trace the approximate locations of several earthquake "clusters" using a marking pen on one of the plastic sheets.

Q5. How are earthquakes distributed on the map?

Q6. Where are they located?

Q7. Where are there no earthquakes?

Q8. Why is it important for us to identify areas which are prone to earthquakes?



http://pubs.usgs.gov/gip/volc/fig34.html

Figure 6. Map of active volcanoes (Red areas represent presence of volcanoes)

2. Study the map of active volcanoes in Figure 6.

Q9. How are volcanoes distributed?

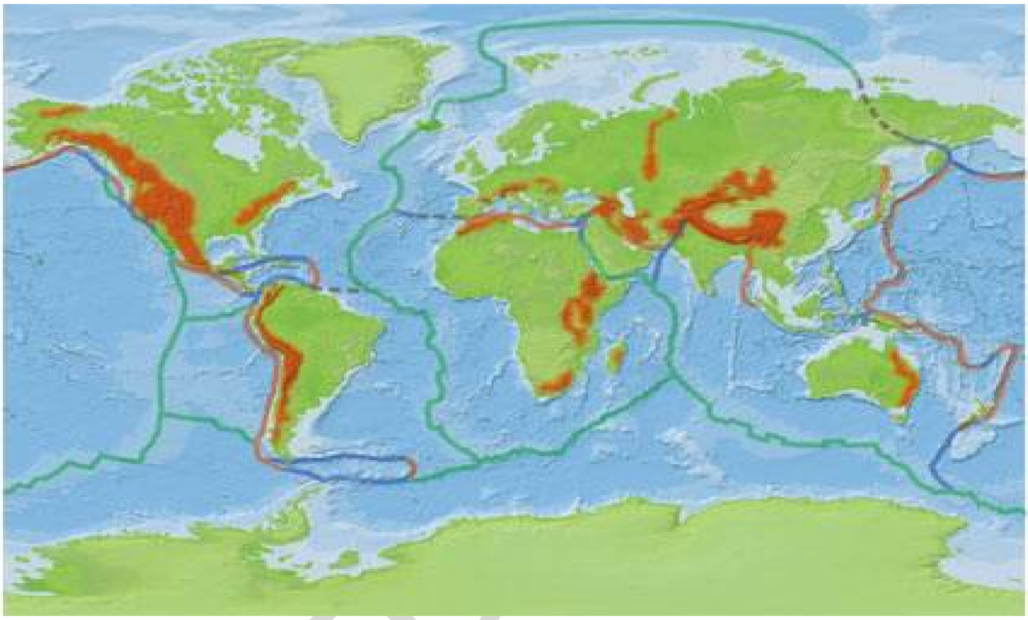
Q10. Where are they located?

Q11. Based on the map, mention a country that is unlikely to experience a volcanic eruption.

3. On the second plastic sheet, sketch the approximate locations of several volcanoes using a marking pen.

4. Place the earthquake plastic sheet over the volcano plastic sheet.

Q12. Compare the location of majority of earthquake epicenters with the location of volcanoes around the world.



http://www.clipart.dk.co.uk/1068/az/Earth/Mountain_ranges

Figure 7. Mountain ranges of the world

5. Study Figure 7, the orange portions indicate mountain ranges of the world.

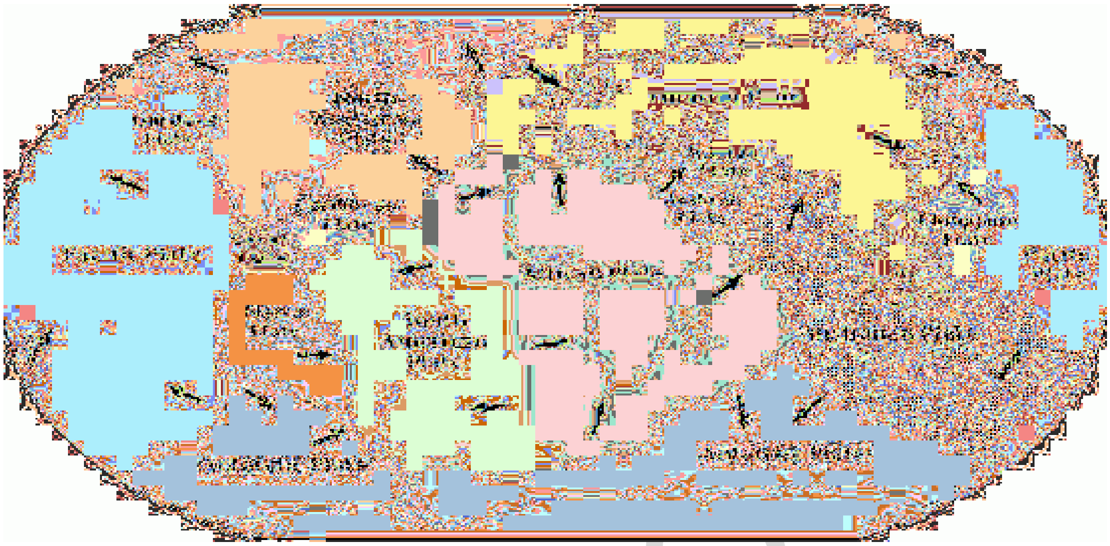
Q13. How will you relate the distribution of mountain ranges with the distribution of earthquake epicenters and volcanoes?

6. Now that you have seen the location of volcanoes, mountain ranges, and majority of earthquake epicenters, study Figure 2 on page 7, Map of Plate boundaries once more.

Q14. What do you think is the basis of scientists in dividing Earth's lithosphere into several plates?

The places on Earth where most of the earthquakes originated or some mountains and volcanoes were formed mark the boundaries of each lithospheric plate. As mentioned earlier, each plate is slowly moving relative to each other, causing geologic events to happen along their boundaries.

Let's take a look at the relative motion of the crustal plates in the figure below.



https://www.bucknell.edu/majors-and-minors/geology/location/geologic-history-of-central-pennsylvania/plate-tectonics.html

Figure 8. Map showing the relative motion of plates (Arrows indicate the direction of motion)

Types of Plate Boundaries

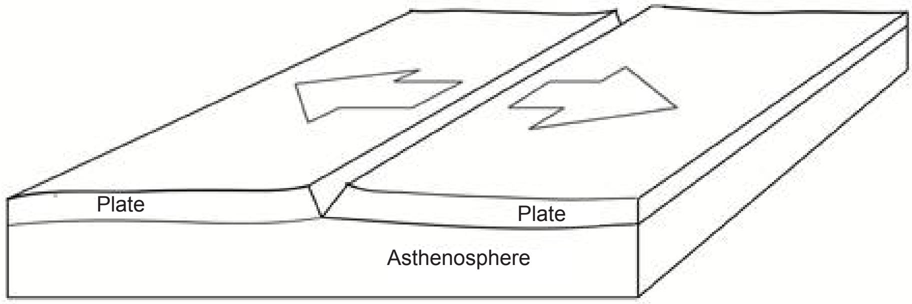
Studying plate boundaries is important because along these boundaries deformation of the lithosphere is happening. These geologic events have a great impact not only on the environment but also on us.

There are three distinct types of plate boundaries, which are differentiated by the type of movement they exhibit.

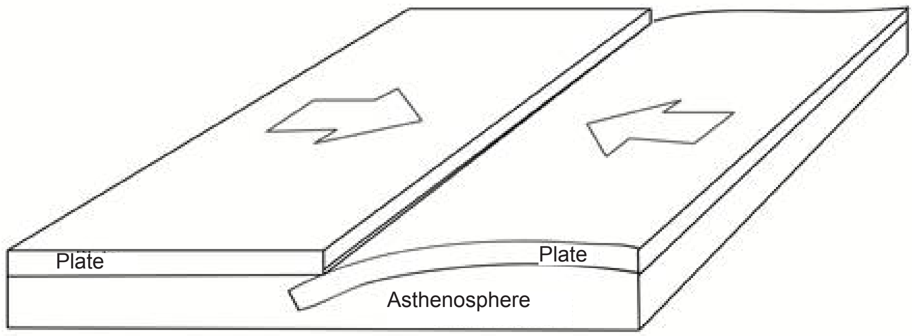
The first type of plate boundary is termed divergent boundary wherein plates move apart, creating a zone of tension. Can you identify adjacent plates depicting divergent boundary on Figure 8?

Let's take the case of the Philippine plate and the Eurasian plate. You will notice that the two plates are moving toward each other. This is an example of a zone where plates collide, and this second type of plate boundary is called convergent plate boundary.

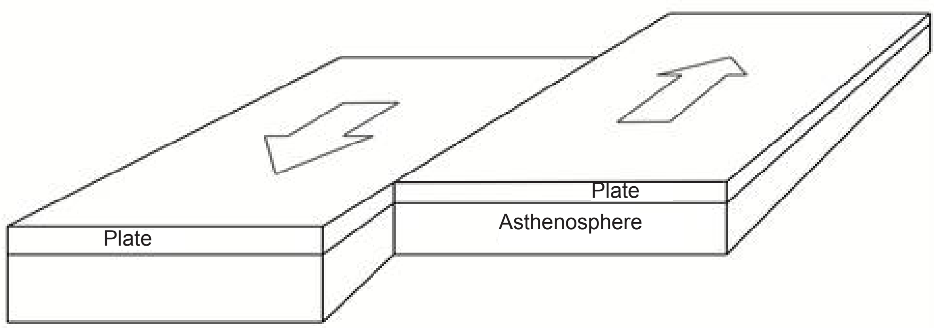
The third type is the transform fault boundary where plates slide or grind past each other without diverging or converging. The best example of this plate boundary is the San Andreas fault which is bounded by the North American plate and the Pacific plate.



A. DIVERGENT PLATE BOUNDARY



B. CONVERGENT PLATE BOUNDARY



C. TRANSFORM FAULT BOUNDARY

http://earthsci8.wikispaces.com/

Figure 9. Three types of Plate Boundaries

After learning the different types of plate boundaries, let us now explore the various effects of plate tectonics on Earth's lithosphere.

Activity 3

Head-On Collision

Part A: Converging Continental Plate and Oceanic Plate

Objectives:

- Explain the processes that occur along convergent boundaries.
- Determine the consequences of colliding plates.

Procedure:

1. Study Figure 10 showing a cross-sectional diagram of plates that are converging, and answer the questions that follow.

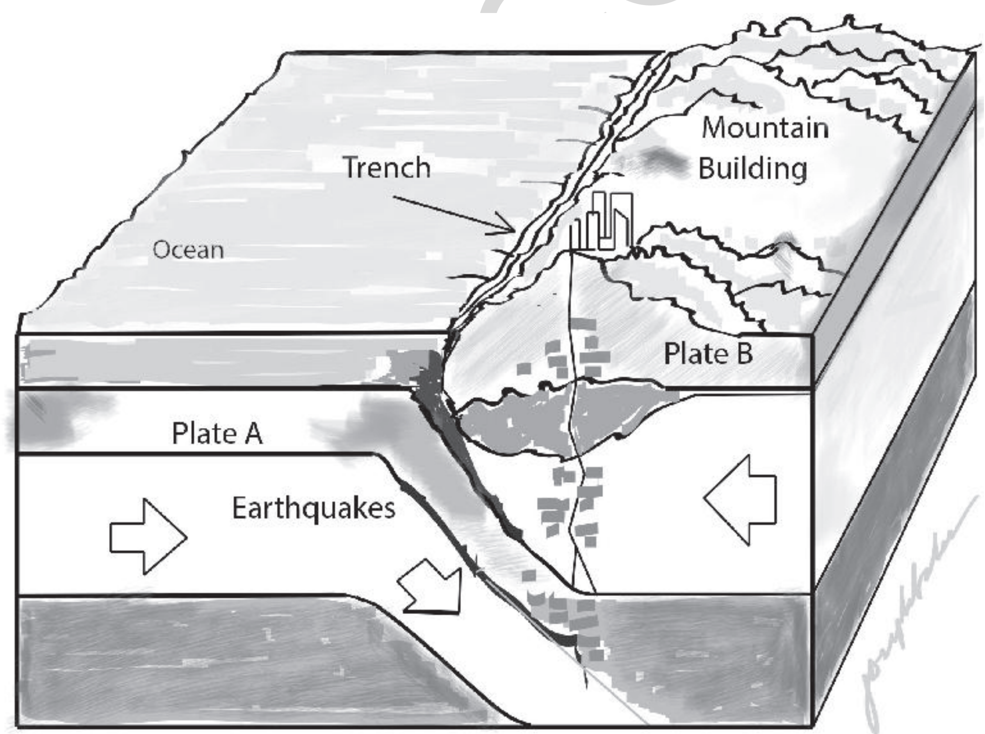


Figure 10. Cross-sectional diagram of converging continental and oceanic plates

Q15. What type of plate is Plate A? What about Plate B? Why do you say so?

Q16. Describe what happens to Plate A as it collides with Plate B? Why?

Q17. What do you think may happen to the leading edge of Plate A as it continues to move downward? Why?

Q18. What do you call this molten material?

Q19. What is formed on top of Plate B?

Q20. As the plates continue to grind against each other, what other geologic event could take place?

Converging Oceanic Crust Leading Plate and Continental Crust Leading Plate

The previous activity depicts what happens during collision of two plates; one has continental edge while the other has an oceanic edge. From the diagram, it is clear that this event gives rise to the formation of a volcanic arc near the edge of a continental leading plate. The reason for this is because the denser oceanic crust (Plate A) undergoes what we call subduction process or the bending of the crust towards the mantle. Since the mantle is hotter than the crust, the tendency is, the subducted crust melt forming magma. Addition of volatile material such as water will cause the magma to become less dense, hence allowing it to rise and reach the crust once again and causing volcanic activities on the continental leading plate.

For the oceanic crust, one important geologic feature is formed, and that is the trench. Also called submarine valleys, ocean trenches are the deepest part of the ocean. One of the deepest is the Philippine trench with a depth of 10 540 meters.

Another subsequent effect of the continuous grinding of plates against each other is the occurrence of earthquakes. The subduction of plate can cause earthquakes at varying depths. Most parts of the world experience occasional shallow earthquakes – where the focus is within 60 km of the Earth's surface. Of the total energy released by earthquakes, 85% comes from shallow earthquakes. Meanwhile, about 12% of energy originates from intermediate earthquakes or those quakes with a focal depth range of 60 to 300 km. Lastly, are the deep earthquakes whose origin is more than 300 km to 700 km below the Earth's surface.

Activity 3

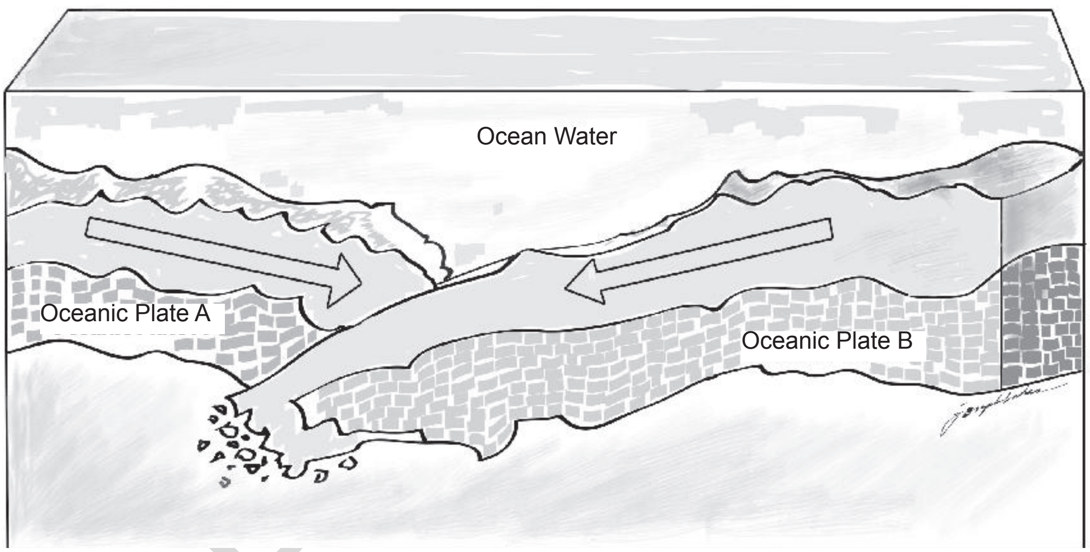
Head-On Collision

Part B: Convergence of Two Oceanic Plates

Procedure:

1. Study Figure 11. It shows a cross-section of two converging oceanic plates.

2. Using your knowledge gained from the previous activity, identify the geologic events or features resulting from this collision.



www.marinebio.net

Figure 11. Cross-sectional diagram of converging oceanic plates

Q21. What are the geologic processes/events that will occur because of this plate movement?

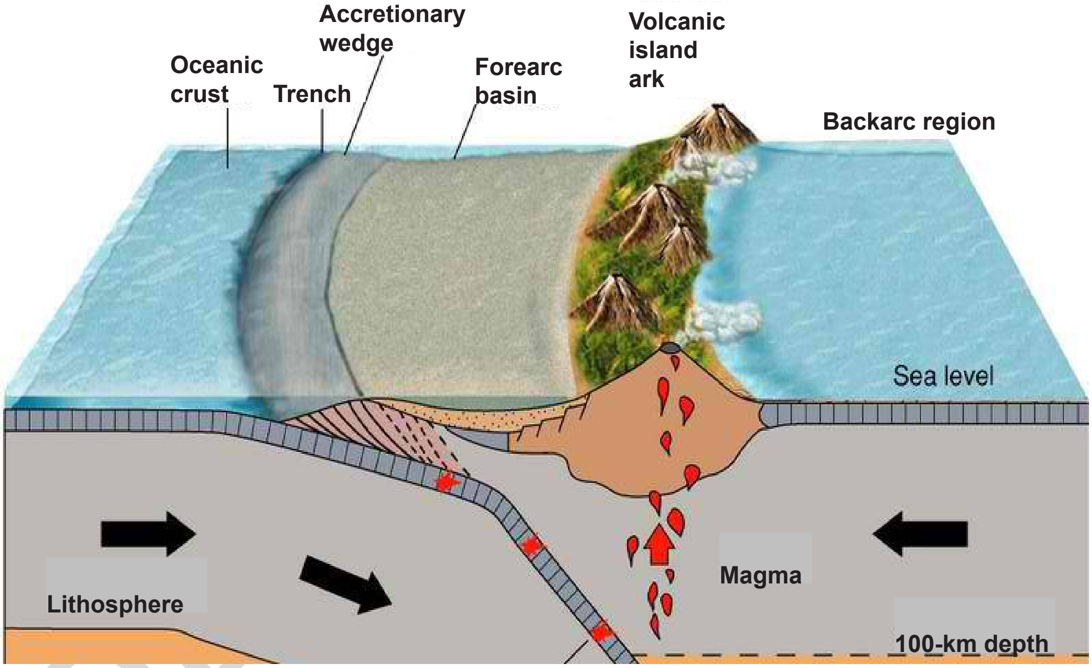
Q22. What geologic features might form at the surface of Plate A?

Q23. If the edge of Plate A suddenly flicks upward, a large amount of water may be displaced. What could be formed at the surface of the ocean?

Convergence of Oceanic Plates

Like the first type of convergent boundaries discussed earlier, converging oceanic plates will cause formation of trenches, and these trenches will become sources of earthquakes. Underwater earthquakes, especially the stronger ones, can generate *tsunamis*. The Japanese term for "harbor wave," *tsunami* is a series of ocean waves with very long wavelengths (typically hundreds of kilometers) caused by large-scale disturbances of the ocean.

The leading edge of the subducted plate will eventually reach the mantle causing it to melt and turn into magma. The molten material will rise to the surface creating a volcanic island arc parallel to the trench. Volcanic island arc is a chain of volcanoes position in an arc shape as seen in figure below.



http://bwbearthenviro2011.wikispaces.com
Figure 12. Formation of a volcanic island arc

Formation of the Philippine Archipelago

Many parts of the Philippines originated from oceanic-oceanic convergence. This resulted from the collision of two oceanic plates, with one of the plates diving under the other.

Majority of the islands in the Philippine archipelago are considered as part of the Philippine Mobile Belt. These islands were formed 65 million years ago at the southern edge of the Philippine Sea Plate and are considered as part of island arcs. Other parts of the Philippines, such as Palawan, Mindoro, and the Zamboanga Peninsula are all highland sections of the Sundaland block of the Eurasian plate (see Figure 13).

Figure 13. Sundaland block of Eurasian Plate which includes Palawan, Mindoro, and Zamboanga

The Philippine Mobile Belt eventually collided with the Sundaland block which explains the presence of trenches, such as the Manila-Negros-Cotabato Trench System, and the Sulu Trench, as shown in Figure 14.

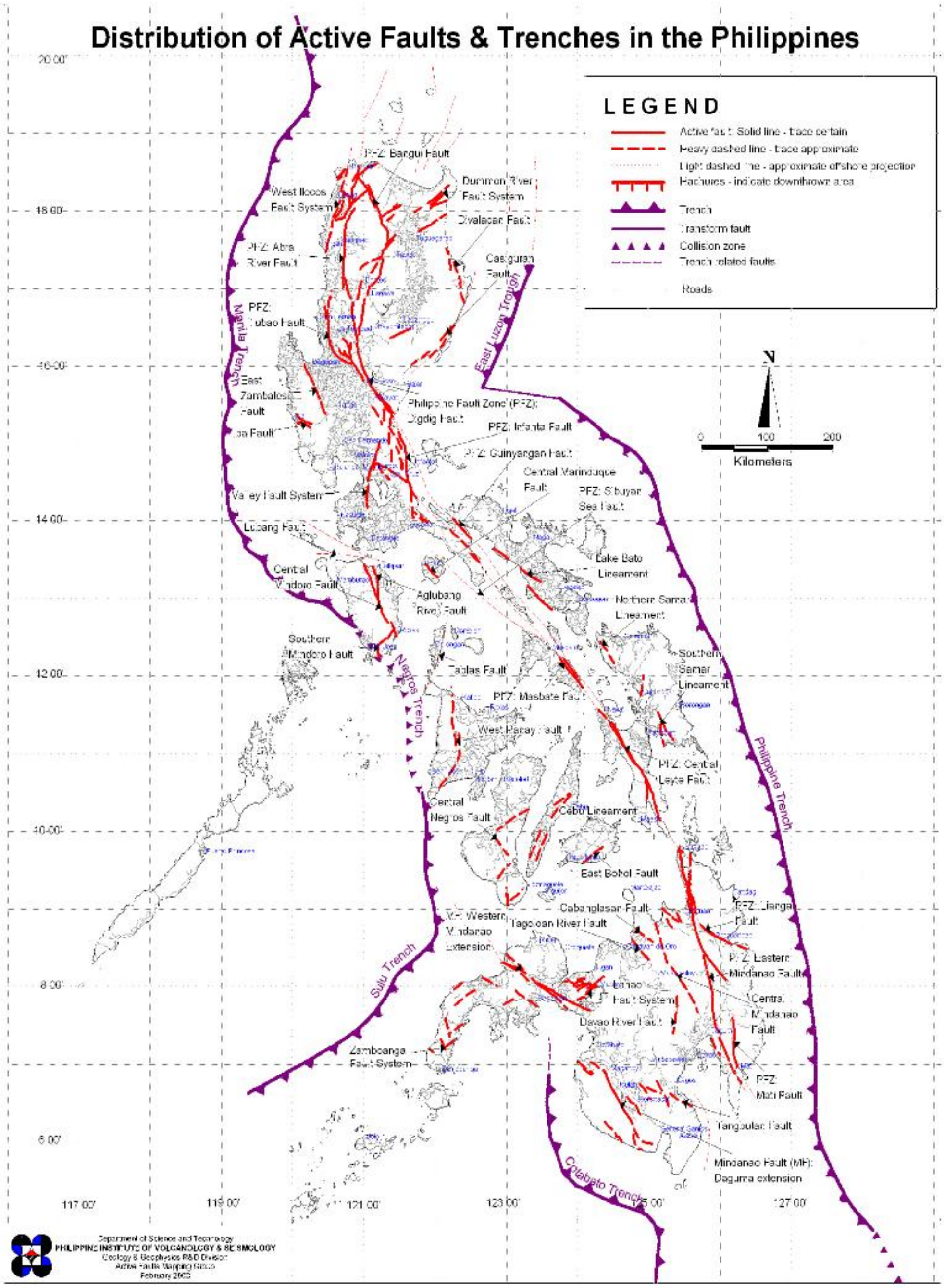
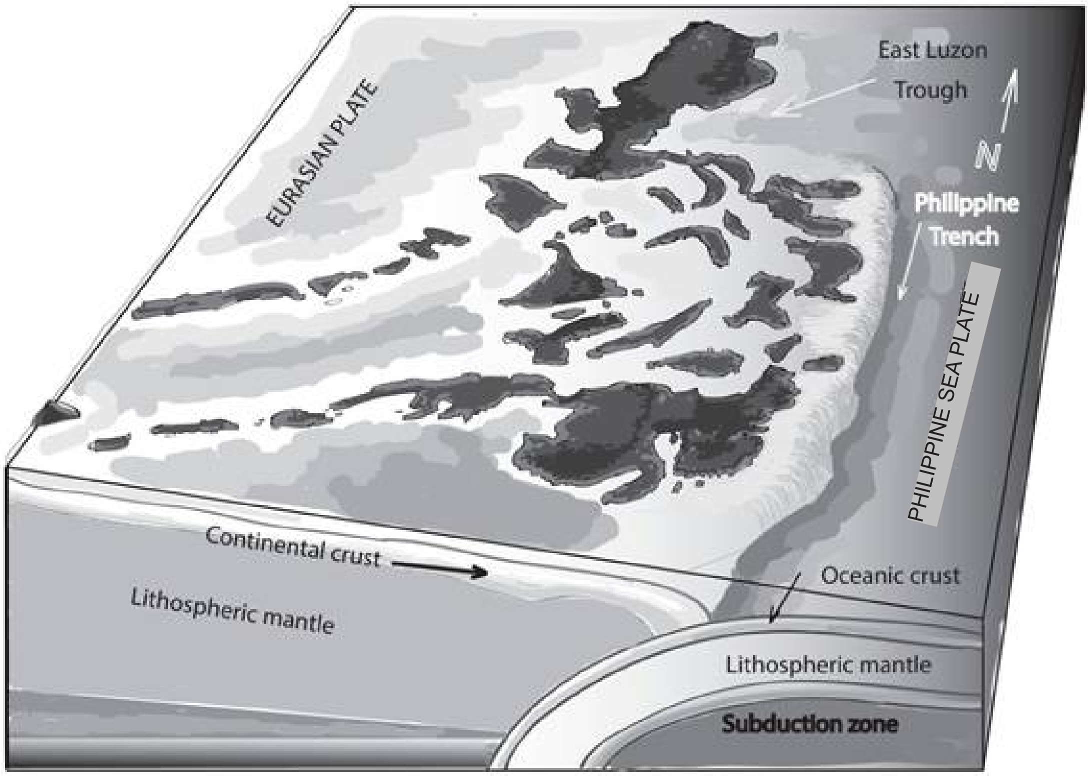


Figure 14. Distribution of Active Faults and Trenches in the Philippines

On the eastern side of the Philippines, trenches like the Philippine Trench and East Luzon Trough are both products of subducting Philippine Sea Plate beneath the archipelago.



http://www.earthobservatory.sg/resources/images-graphics/subduction-zone-beneath-philippines
Figure 15. Subduction of Philippine Sea Plate

Aside from the formation of trenches and troughs, the downward movement of oceanic lithospheres underneath the Philippine Archipelago creates active volcanic chains. For example, the descent of the West Philippine Sea oceanic lithosphere along the Manila Trench created a volcanic chain from Taiwan to Mindoro. Some of the known active volcanoes in this chain are Pinatubo in Central Luzon and Taal in Batangas.

Also, the constant dipping movement of slabs induces frequent moderate to strong earthquakes at various depths, gives rise to mountain ranges and develops the geologic character of the Philippine Archipelago.

Activity 3

Head-On Collision

Part C: Two Continental Plates Converging

Materials:

- modeling clay
- 2 blocks of wood
- paper

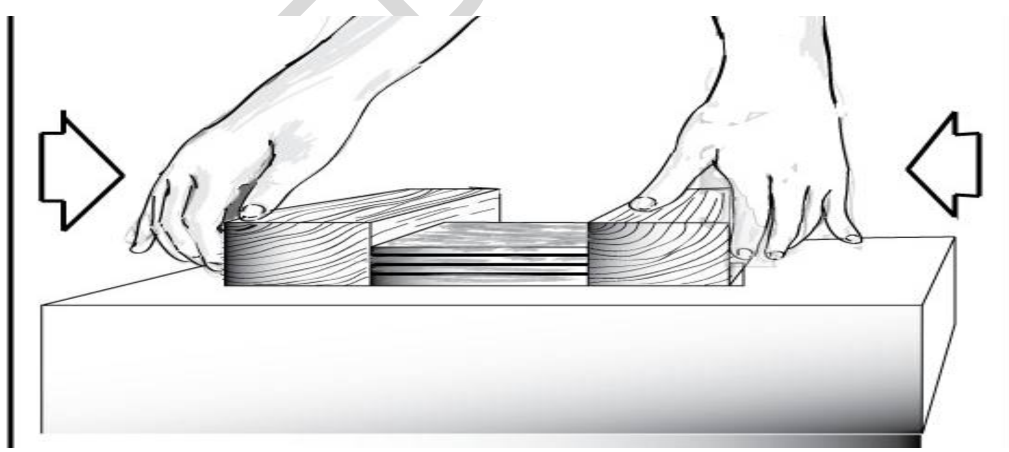
Procedure:

1. On a piece of paper, flatten the modeling clay with the palm of your hand.

2. Cut the clay into four strips; each strip should be 0.5 cm thick, 4 cm wide, and 12 cm long.

3. Put 4 strips one on top of the other.

4. Place a block of wood at each end of the clay strips and slowly push the two blocks together. Observe what happens to the clay.



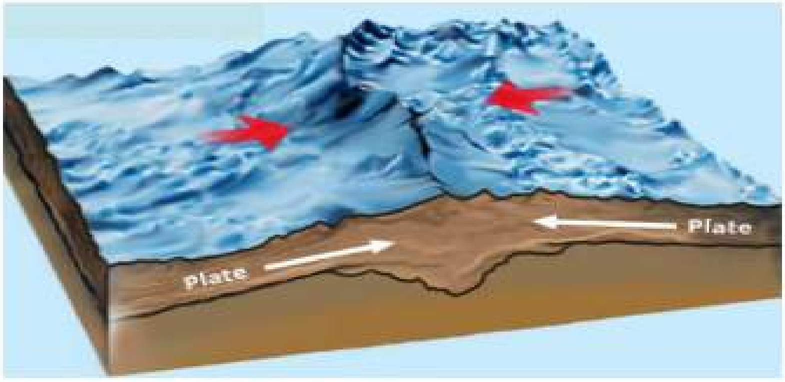
Q24. What happened to the strips of clay as they were pushed from opposite ends?

Q25. If the strips of clay represent the Earth's lithosphere, what do you think is formed in the lithosphere?

Q26. What other geologic event could take place with this type of plate movement aside from your answer in Q25?

Q27. In terms of the consequences on the Earth's lithosphere, how will you differentiate this type of convergent plate boundary with the other two?

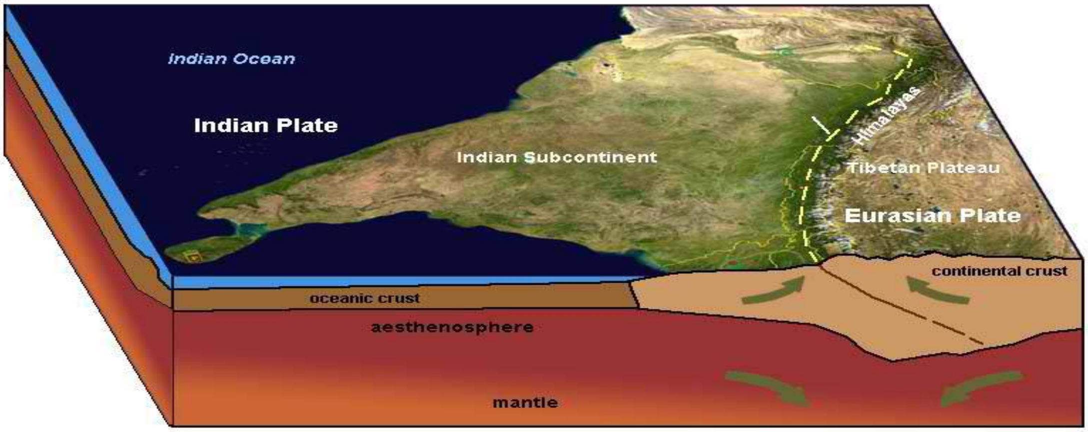
When two continental plates converge, a collision zone is formed. Unlike the other two types of convergent boundaries, subduction ceases for this particular type of convergence. No trench, no volcano, and definitely no island arc are created during this process. Instead, what is created is a large group of tall mountains called mountain range.



http://whybecausescience.com/category/vulcanism/
Figure 16. Formation of mountain range

About 40 to 50 million years ago, two large land masses, India and Eurasia, collided to begin the formation of the most visible product of plate tectonics - the Himalayas. Since subduction is impossible between two colliding continental plates, pressure is released by pushing the crusts upward and forming the Himalayan peaks.

Also, collision of continental plates is associated with shallow earthquake activities.



http://pubs.usgs.gov/
Figure 17. Collision of the Eurasian and Indian plates

After learning the effects of convergent plate boundaries on the Earth's lithosphere, it's time for us to move on to the next type of plate boundary: the divergent plate boundary.

Activity 4

Going Separate Ways

Objectives:

- Explain the processes that occur along divergent boundaries.
- Determine the results of plates that are moving apart.

Materials:

photographs of Rift Valleys and Oceanic Ridges

Procedure:

1. Analyze the photographs of rift valleys (topmost pictures) and oceanic ridges below, and answer the questions that follow.

http://www.adelaidenow.com.au/, http://www.wildjunket.com/, http://www.jnb-birds.com/
Figure 18. Rift valleys and oceanic ridges

Q28. What are common in the four pictures?

Q29. Millions of years ago, the land masses in each picture were once connected. What do you think is happening to the Earth's crust in those pictures?

Q30. If this event continues for millions of years, what do you think will be the effect on the crust?

Q31. Complete the drawing below to illustrate your answer in question number 30.

At present

After millions of years

Divergence of Plates

Formation of rift valleys and oceanic ridges are indications that the crust is spreading or splitting apart. In this case, the plates are forming divergent plate boundaries wherein they tend to move apart. Most divergent boundaries are situated along underwater mountain ranges called oceanic ridges. As the plates separate, new materials from the mantle ooze up to fill the gap. These materials will slowly cool to produce new ocean floor.

The spreading rate at these ridges may vary from 2 to 20 cm per year. Although a very slow process, divergence of plates ensures a continuous supply of new materials from the mantle. The Mid-Atlantic Ocean ridge is an example of spreading center which causes the divergence of the South American plate and the African plate.

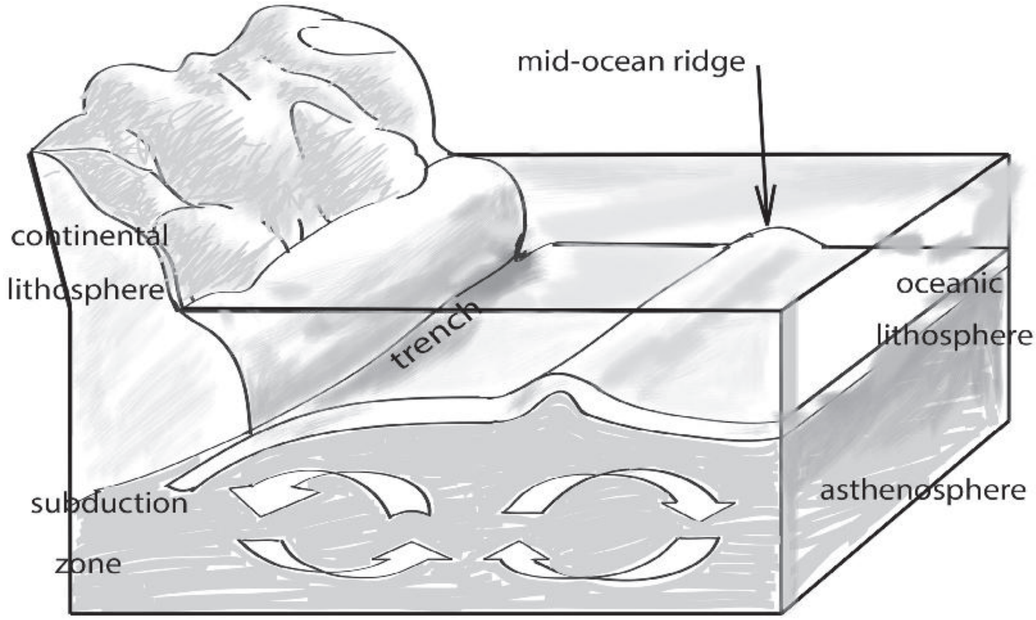
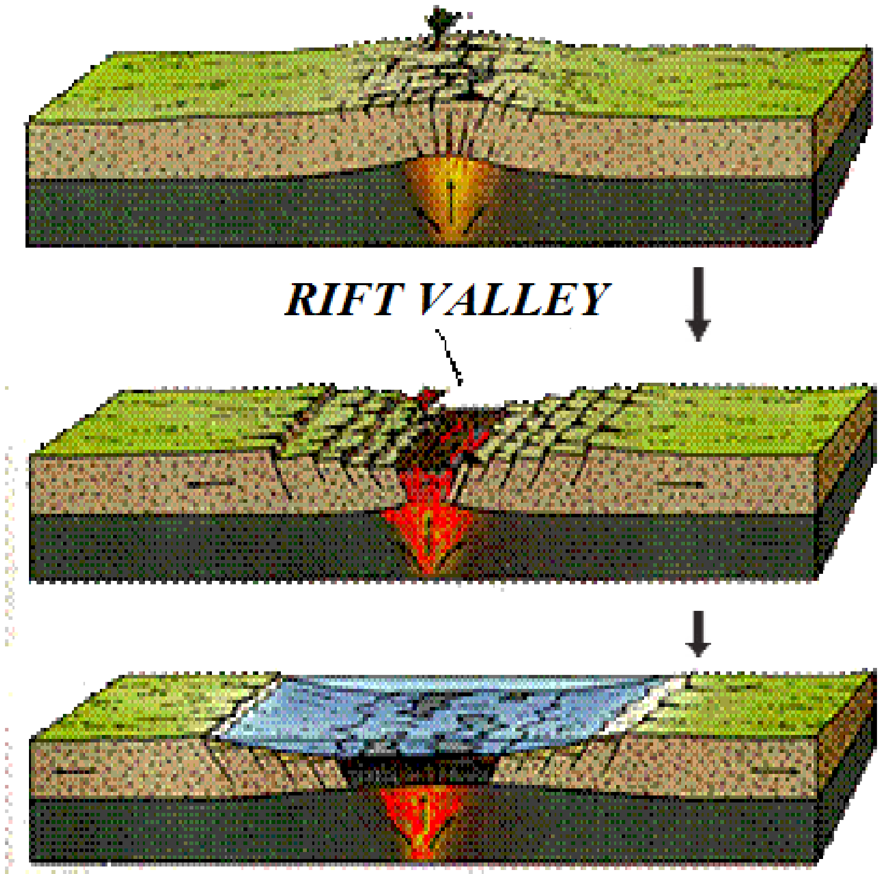


Figure 19. Formation of Mid-Ocean ridge (Diagram by Phyllis Newbill)

When a spreading center develops within a continent, the crust may break into several segments. The breaking leads to the formation of down faulted valleys called rift valleys. It is also associated with the rising of hot materials from the mantle.

The rift valley increases its length and depth as the spreading continues. At this point, the valley develops into a linear sea, similar to the Red Sea today.



http://www.moorlandschool.co.uk/earth/tectonic.htm
Figure 20. Development of a rift valley

In Grade 8, you were introduced to different types of fault such as normal, reverse, and strike-slip. You also learned that faults are fractures in the Earth's crust created by different types of forces acting on the lithosphere.

There is one type of plate boundary that resembles the strike-slip fault. Though much larger, transform fault boundary is similar to strike-slip fault in terms of the relative motion of adjacent slabs of rock.

To find out more about this kind of plate boundary, the next activity will let you simulate the event that could happen out of this boundary.

Activity 5

Slide and Shake

Objective:

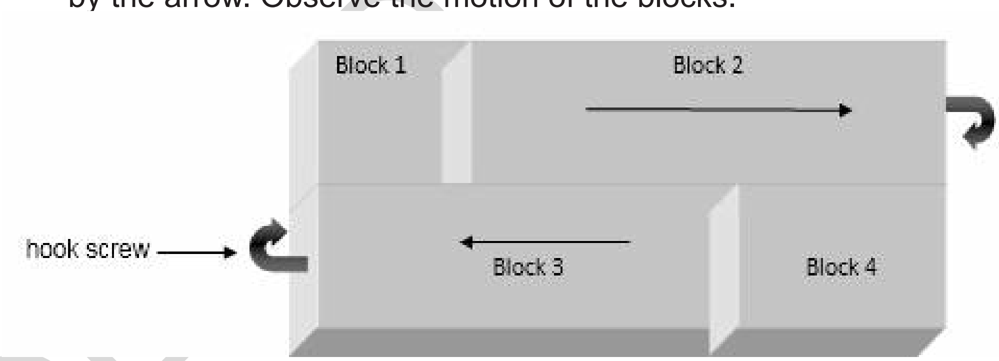
determine the effect of transform-fault boundary on the Earth's crust.

Materials:

- four blocks of wood:
  blocks 1 and 4 measures 5 cm x 5 cm x 10 cm
  while blocks 2 and 3 measures 5 cm x 5 cm x 15 cm
- two hook screws
- sandpaper

Procedure:

1. Attach a hook screw on one end of Blocks 2 and 3.
2. Arrange the blocks as shown in the illustration below.
3. Place sandpaper on the side of the blocks where they all meet.
4. Slowly pull Blocks 2 and 3 on its hook screw to the direction indicated by the arrow. Observe the motion of the blocks.



Q32. Were you able to pull the blocks of wood easily? Why or why not?

Q33. What can you say about the relative motion of blocks 1 and 2? How about blocks 3 and 4?

Q34. How will you describe the interaction between blocks 2 and 3 as you pull each block?

Q35. What is the interaction between blocks 1 and 3? How about between blocks 2 and 4?

Transform Fault Boundaries

If the blocks of wood in Activity 6 were to represent the lithospheric plates, you will notice that there were two sets of divergent plate boundaries (between blocks 1 and 2, and blocks 3 and 4). But since the plates were adjacent to each other, a new type of boundary is manifested and that is the transform fault boundary.

Most transform faults join two segments of a mid-ocean ridge (represented by the gaps between 1 and 2, and between 3 and 4). Remember that the presence of a ridge is an indication of diverging plates, and as the plates diverge between the two segments of the mid-ocean ridge, the adjacent slabs of crust are grinding past each other (blocks 2 and 3, blocks 1 and 3, and blocks 2 and 4).

Although most transform faults are located within the ocean basins, there are a few that cut through the continental crust. An example of this is the San Andreas fault. The immediate concerns about transform fault boundaries are earthquake activities triggered by movements along the fault system.

sanandreasfault.org

Figure 21. San Andreas Fault

It was stated at the beginning of this module that majority of tectonic activities like earthquakes, mountain formations, and volcanic activities happen along or near plate boundaries. But there are some cases wherein activities take place in the middle of a plate.

Let's take the case of the Hawaiian islands. Here, we can find some of the largest and most active volcanoes of the world. If we're going to look at Hawaii, it is situated right in the middle of Pacific plate and not along the boundaries.

What causes the formation of this chain of volcanic islands? The answer lies in an area called hot spot. To better understand this, let's perform the next activity.

Activity 6

Drop It Like It's "Hot Spot"

Objective:

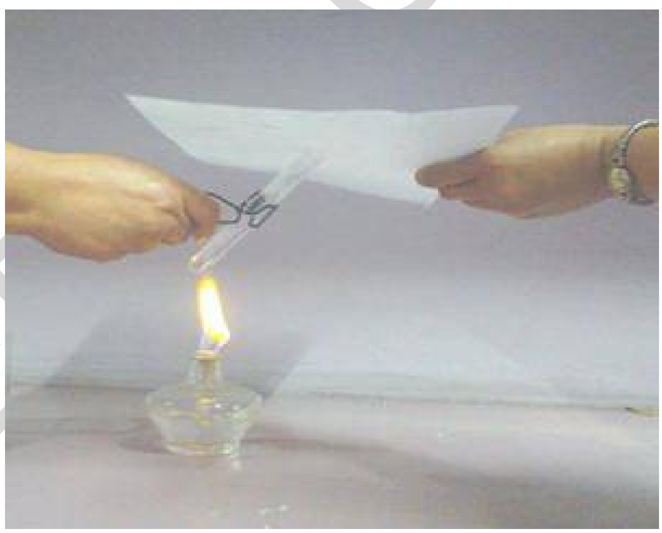
Relate hot spot with plate tectonics

Materials:

- alcohol lamp
- bond paper (2 sheets)
- test tube
- match
- test tube holder
- water

Procedure:

1. Attach one end of the bond paper to the end of another bond paper.
2. Fill 3/4 of the test tube with water and heat it over an alcohol lamp.
3. While waiting for the water to boil, place the paper on top of the test tube. Be sure that the two are in contact.



4. Once the water starts boiling and fumes are coming out, hold the paper in the same position for the next 10 seconds.
5. After 10 seconds, move the bond paper very slowly and horizontally by 10 centimeters. See to it that the paper and test tube are still in contact.
6. Repeat step 5 after another 10 seconds and observe.

   Q36. What can you see on the surface of the bond paper?

Q37. Let's say that the paper represents the Earth's crust; what do you think is represented by the water in the test tube?

Q38. What geologic feature do you think will be formed at the surface of the crust?

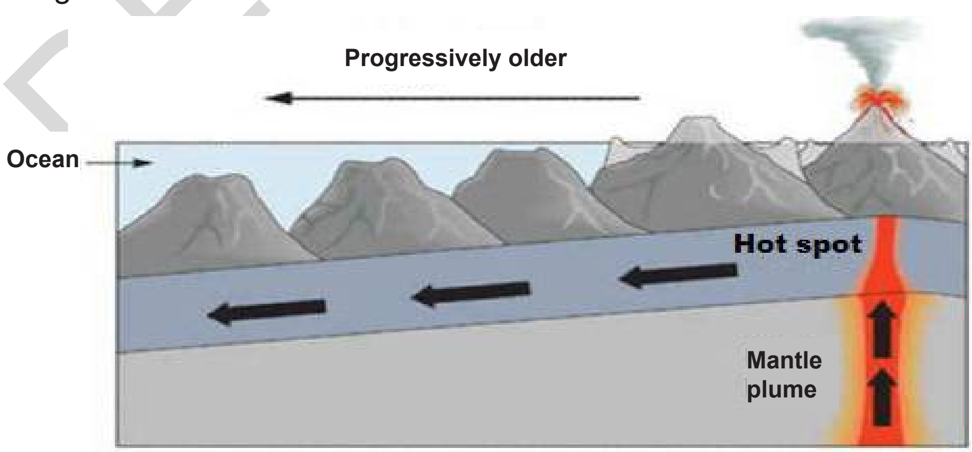
Q39. Which of the features, at the surface of the crust, will be the oldest? the youngest? Label these on your paper.

Q40. Which of the features will be the most active? The least active? Label these on your paper.

Activity 6 gave you an idea how tectonic activities could also happen within a plate and not just along the boundaries.

This idea started when extensive mapping of seafloor volcanoes in the Pacific revealed a chain of volcanic structures extending from the Hawaiian Islands to Midway Islands. When geologists determined the age of each volcanic island through radiometric dating, they noticed that the farther the volcano from Hawaii is, the older and less active it is.

Scientists suggested that there is a source of molten materials from the mantle called mantle plume that formed the volcanic island chains. As the Pacific plate moves, different parts of it will be on top of the mantle plume to receive the molten materials, thus creating the volcanic islands. Continuing plate movement eventually carries the island beyond the hot spot, cutting it off from the magma source, and volcanism ceases. As one island volcano becomes extinct, another develops over the hot spot, and the cycle is repeated. This process of volcano growth and death, over many millions of years, has left a long trail of volcanic islands and seamounts across the Pacific Ocean floor.



http://www.geo.hunter.cuny.edu/
Figure 22. Hot spot forming a chain of volcanoes

Performance Task

At this point, we are quite aware that our country is susceptible to different disasters such as earthquakes, volcanic eruptions, and *tsunamis*. Therefore, it is a must for us to prepare and ensure our safety and survival when these disasters strike.

For this activity, your goal is to help your family prepare for an impending emergency. Your task is to prepare an emergency kit for the whole family. Decide what items should be in your emergency kit and be ready to present it in class.

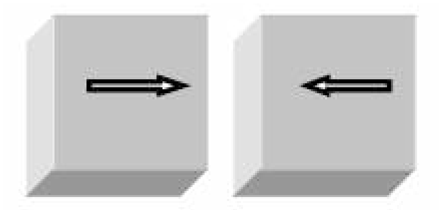
The scoring rubric below will be used in assessing your kit.

	1 pt.	2 pts.	3 pts.	4 pts.
Survival Kit Items	None of the items are necessary for survival during or after a disaster.	A few of the items are clearly necessary for survival during or after a disaster.	At least 8 items are clearly necessary for survival during or after a disaster.	At least 10 items are clearly necessary for survival during or after a disaster.
Labels and Uses	None of the items are labeled properly and there is no reason for including it in the survival kit.	A few of the items are labeled properly and a reason for each item is included on a separate sheet of paper.	At least 8 of the items are labeled properly and a reason for each item is included on a separate sheet of paper.	At least 10 items are labeled properly and a reason for each item is stated on a separate sheet of paper.
	1 pt.	2 pts.	3 pts.	4 pts.
Neatness and Effort exerted	The kit is not organized. It looks like the student threw it together at the last minute without much care.	The kit is somewhat organized and it looks like the student ran out of time or didn't take care of the project.	The kit is done well with some organization and labeling. It appears the student worked hard on it.	The kit is neatly organized and labeled as necessary. Much time and effort were put into creating this project.

V. Summative Assessment

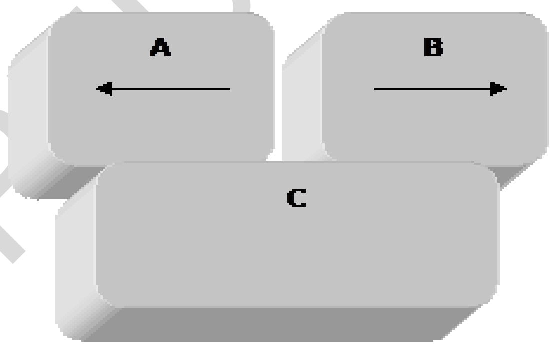
Directions: Answer the following questions;

1. Predict what geologic features could result out of this plate boundary (three possible answers).



2. In a hot spot, Volcano A is on top of the mantle plume, Volcano B is 10 km farther from A while Volcano C is the farthest. What can you infer about the ages of the volcanoes?
   a. Volcano A is older than C c. Volcano B is the youngest
   b. Volcano B is the oldest d. Volcano B is younger than C

3. Right in the middle of an island, you can find a rift valley. What type of plate boundary exists on that island?
   a. convergent b. divergent c. normal fault d. transform fault



4. Plates A and B shows a divergent boundary. If plate C is adjacent to both plates and does not show any relative motion, what type of plate boundary is present between A and C? ___________________

5. What geologic event is most likely to happen at the given type of plate boundary in number 4?
   a. earthquake c. rift valley formation
   b. mountain formation d. volcanic eruption

6. You were asked to locate the epicenter of a recent earthquake. Which correct sequence of events should you follow?

   i. Determine the difference in the arrival time of S and P waves recorded from each of the seismological stations.
   ii. Use the triangulation method to locate the center.
   iii. Obtain data from three different seismological stations.
   iv. Determine the distance of the epicenter from the station.

   a. i, iii, ii, iv b. iii, i, iv, ii c. iii, iv, i, ii d. iv, ii, i, iii

7. What do you expect to find parallel to a trench?
   a. hot spot b. ocean ridge c. rift valley d. volcanic arc

Matching type:
Match column A with columns B and C

A	B	C
Type of Plate Boundary	Relative Motion of the Plates	Geologic Features/ Events Present
8. Divergent	a. Moving away from each other	d. Earthquakes
9. Convergent	b. Moving towards each other	e. Mountains, volcanoes, trenches, and earthquakes
10. Transform fault	c. Sliding past each other	f. Rift valleys, oceanic ridges, and earthquakes

VI. Summary/Synthesis/Feedback

- According to the plate tectonics model, the entire lithosphere of the Earth is broken into numerous segments called plates.
- Each plate is slowly but continuously moving.
- As a result of the motion of the plates, three types of plate boundaries were formed: Divergent, Convergent, and Transform fault boundaries.
- Divergent boundary is formed when plates move apart, creating a zone of tension.
- Convergent boundary is present when two plates collide.
- Transform fault is characterized by plates that are sliding past each other.
- Plate tectonics give rise to several geologic features and events.

Glossary of Terms

Continental volcanic arc	mountains formed in part by igneous activity associated with subduction of oceanic lithosphere beneath a continent
Convergent boundary	a boundary in which two plates move toward each other, causing one of the slabs of the lithosphere to subduct beneath an overriding plate
Crust	the outer portion of the earth
Continental Crust	the thick part of the Earth's crust, not located under the ocean
Oceanic Crust	the thin part of the Earth's crust located under the oceans
Divergent boundary	a region where the crustal plates are moving apart
Earthquake	vibration of Earth due to the rapid release of energy
Fault	a break in a rock along which movement has occurred
Fracture	any break in a rock in which no significant movement has taken place
Geology	the science that studies Earth
Hot spot	a concentration of heat in the mantle capable of creating magma
Magma	a mass of molten rock formed at depth, including dissolved gases and crystals.
Mid-ocean ridge	a continuous mass of land with long width and height on the ocean floor.
Plates	rigid sections of the lithosphere that move as a unit
Plate tectonics	a theory which suggests that Earth's crust is made up of plates that interact in various ways, thus producing earthquakes, mountains, volcanoes, and other geologic features

Primary (P) wave	the first type of seismic wave to be recorded in a seismic station
Rocks	consolidated mixture of minerals
Secondary (S) wave	second type of earthquake wave to be recorded in a seismic station
Seismogram	a record made by a seismograph
Seismograph	a device used to record earthquake waves
Subduction	an event in which a slab of rock thrusts into the mantle
Transform fault boundary	a boundary produced when two plates slide past each other
Trench	a depression in the seafloor produced by subduction process
Volcanic Island arc	a chain of volcanoes that develop parallel to a trench

References and Links

Printed Materials:

Department of Education, Bureau of Secondary Education. Project EASE Integrated Science 1, Module 12: Inside the Earth.

Department of Education, Bureau of Secondary Education (2013). *Science - Grade 8 Learner's Module.* Vibal Publishing House, Inc.

Punongbayan, R. et al. (1998). The Philippine Archipelago Volume 1.

Tarbuck, E.J. et al. (2009). *Earth Science 12th ed*. Pearson Education South Asia Pte Ltd.

Yumul, Jr., Graciano P., Carla B. Dimalanta, Victor B. Maglambayan and Edanjarlo J. Marquez, *Tectonic Setting of a Composite Terrane: A Review of the Philippine Island Arc System*, 12 Geosciences Journal 1, (March 2008), pp. 7−17.

Robert Hall, *Reconstructing Cenozoic SE Asia*

Electronic Sources:

http://www.palawan.nfo.ph/geology/ accessed August 20, 2014

http://www.skoool.ie/ accessed March 3, 2014

http://earthds.info/ accessed March 3, 2014

http://eqseis.geosc.psu.edu/ accessed March 4, 2014

http://www.platetectonics.com/ accessed March 5, 2014

http://geology.com/ accessed March 5, 2014

http://www.nws.noaa.gov/ accessed March 6, 2014

http://csep10.phys.utk.edu/ accessed March 6, 2014

http://pubs.usgs.gov/ accessed March 6, 2014

http://www.moorlandschool.co.uk/earth/tectonic.htm accessed March 7,

http://stream2.cma.gov.cn/pub/comet/Environment/TsunamiWarningSystems accessed March 3 2014

https://www.bucknell.edu/majors-and-minors/geology/location/geologic-history-of-central-pennsylvania/plate-tectonics.html accessed July 1, 2014

http://earthquake.usgs.gov

http://pubs.usgs.gov/gip/volc/fig34.html

http://www.clipart.dk.co.uk/1068/az/Earth/Mountain_ranges

http://earthsci8.wikispaces.com

www.maribio.net

http://bwbearthenviro2011.wikispaces.com

http://www.earthobservatory.sg/resources/images-graphics/subduction-zone-beneath-philippines

http://whybecausescience.com/category/vulcanism

http://www.adelaidenow.com.au/

http://www.wildjunket.com/

http://www.jnb-birds.com/

http://www.radford.edu/jtso/GeologyofVirginia/Tectonics/GeologyofVATectonics6-1c.html

sanandreasfault.org

http://www.geo.hunter.cuny.edu/

Unit 1
MODULE

2

Suggested time allotment: 15-18 hours

THE EARTH'S INTERIOR

I. Introduction

Scientists have studied heavenly bodies which are millions of miles away from Earth. Equipped with powerful telescopes and space probes, they were able to reach and examine the solar system and beyond. It seems ironic then, that we haven't, and we couldn't reach the center of our very own planet.

In Module 1, you have learned about the different processes and landforms along plate boundaries that slowly shaped the Earth's surface. In Module 2, you will learn the connection between these processes with the internal structure and mechanisms of our planet.

This module will help you visualize and understand the composition and structure of the Earth's interior. It provides you scientific knowledge that will help you describe the different layers of the Earth as well as understand their characteristics. You will also learn concepts that explain the physical changes that it underwent in the past. This module also consists of activities that will help you develop your critical thinking skills to have a deeper understanding about the planet where you live.

At the end of this module, you will be able to answer the following key questions:

1. How do the structure and composition of the Earth cause geologic activities and physical changes?
2. What are the possible causes of the lithospheric plate movements?
3. What proves the movement of the tectonic plates?

II. Learning Competencies/Objectives

In this module, you should be able to:

1. Describe the internal structure of the Earth.
2. Discuss the possible causes of plate movement.
3. Enumerate the lines of evidence that support plate movement.

III. Pre-Assessment

Directions:
A. Choose the letter of the correct answer.
For questions 1 and 2, refer to the figure below that shows the cross section of the Earth as seismic waves travel through it.

Seismic waves as they travel through the Earth

1. An S-wave shadow zone is formed as seismic waves travel through the Earth's body. Which of the following statements does this S-wave shadow zone indicate?
   a. The inner core is liquid.
   b. The inner core is solid.
   c. The mantle is solid.
   d. The outer core is liquid.

2. Why are there no P-waves or S-waves received in the P-wave shadow zone?
   a. P-waves are absorbed and S-waves are refracted by Earth's outer core.
   b. P-waves are refracted and S-waves are absorbed by Earth's outer core.
   c. Both the P-waves and S-waves are refracted by Earth's outer core.
   d. Both the P-waves and S-waves are absorbed by Earth's outer core.

3. What makes up the lithosphere?
   a. Continental crust
   b. Crust and the upper mantle
   c. Oceanic crust and continental crust
   d. Upper mantle

4. Miners dig into the Earth in search for precious rocks and minerals. In which layer is the deepest explorations made by miners?
   a. Crust
   b. Inner core
   c. Mantle
   d. Outer core

5. How do you compare the densities of the Earth's crust, mantle, and core?
   a. The mantle is less dense than the core but denser than the crust.
   b. The mantle is less dense than both the core and the crust.
   c. The mantle is denser than the core but less dense than the crust.
   d. The mantle is denser than both the core and the crust.

6. The movement of the lithospheric plates is facilitated by a soft, weak and plastic-like layer. Which of the following layers is described in the statement?
   a. Asthenosphere
   b. Atmosphere
   c. Lithosphere
   d. Mantle

7. Alfred Wegener is a German scientist who hypothesized that the Earth was once made up of a single large landmass called Pangaea. Which of the following theories did Wegener propose?
   a. Continental Drift Theory
   b. Continental Shift Theory
   c. Plate Tectonics
   d. Seafloor Spreading Theory

8. If you are a cartographer, what will give you an idea that the continents were once joined?
   a. Ocean depth
   b. Position of the south pole
   c. Shape of the continents
   d. Size of the Atlantic Ocean

9. Which observation was NOT instrumental in formulating the hypothesis of seafloor spreading?
   a. Depth of the ocean
   b. Identifying the location of glacial deposits
   c. Magnetization of the oceanic crust
   d. Thickness of seafloor sediments

10. As a new seafloor is formed at the mid-ocean ridge, the old seafloor farthest from the ridge is destroyed. Which of the stated processes describes how the oceanic crust plunges into the Earth and destroyed at the mantle?
   a. Convection
   b. Construction
   c. Diversion
   d. Subduction

B. Answer briefly the following questions.

1. What are the different layers of the Earth?
2. Why is there a need to study the Earth's layers?
3. What proves the existence of the boundary between the crust and the mantle?
4. What are the characteristics of the asthenosphere?
5. What do the shapes of the continents now tell us about their past?

IV. Reading Resources and Instructional Activities

Studying the Earth's Interior

Scientists tried to explore and study the interior of the Earth. Yet, until today, there are no mechanical probes or actual explorations done to totally discover the deepest region of the Earth.

The Earth is made up of three layers: the crust, the mantle, and the core. The study of these layers is mostly done in the Earth's crust since mechanical probes are impossible due to the tremendous heat and very high pressure underneath the Earth's surface.

In Grade 8, it was mentioned that seismic waves from earthquakes are used to analyze the composition and internal structure of the Earth.

What are seismic waves?

You learned that an earthquake is a vibration of the Earth produced by the rapid release of energy most often because of the slippage along a fault in the Earth's crust. This energy radiates in all directions from the focus in the form of waves called seismic waves, which are recorded in seismographs.

The two main types of seismic waves are body waves and surface waves.

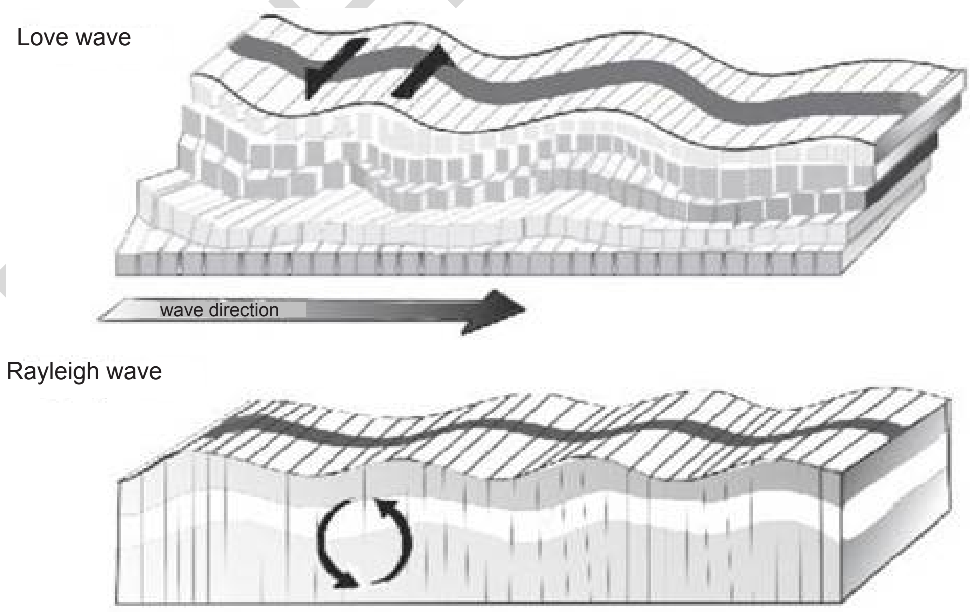


Figure 1. Surface Waves

Surface waves can only travel through the surface of the Earth. They arrive after the main P and S waves and are confined to the outer layers of the Earth. There are two types of surface waves: the Love waves and the Rayleigh waves. Love wave is named after A.E.H. Love, a British mathematician who worked out the mathematical model for this kind of wave in 1911. It is faster than Rayleigh wave and it moves the ground in a side-to-side horizontal motion, like that of a snake's causing the ground to twist. This is why Love waves cause the most damage to structures during an earthquake.

The other kind of surface wave is the Rayleigh wave. It was named after John William Strutt, Lord Rayleigh, who mathematically predicted the existence of this kind of wave in 1885. A Rayleigh wave rolls along the ground just like a wave rolls across a lake or an ocean. Since it rolls, it moves the ground either up and down or side-to-side similar to the direction of the wave's movement. Most of the shaking felt from an earthquake is due to the Rayleigh wave.

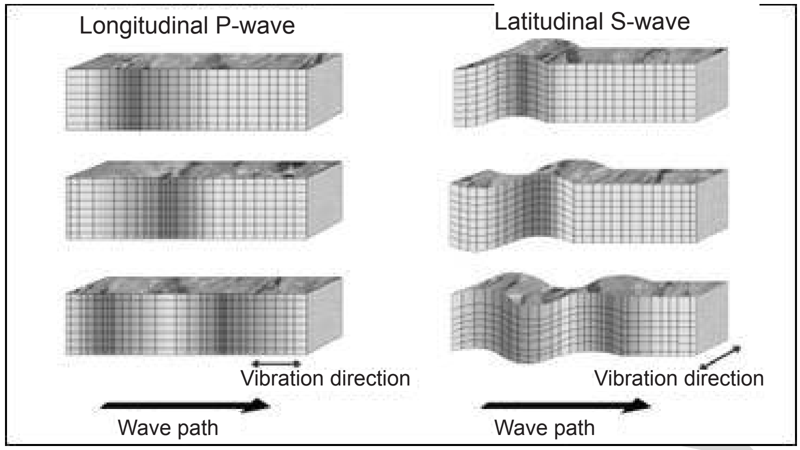
Unlike surface waves, body waves can travel through the Earth's inner layers. With this characteristic of the body waves, they are used by scientists to study the Earth's interior. These waves are of a higher frequency than the surface waves.

The two types of body waves are the P-waves (primary waves) and the S-waves (secondary waves).

What are P and S-waves?

The P-wave (primary wave) is a pulse energy that travels quickly through the Earth and through liquids. The P-wave travels faster than the S-wave. After an earthquake, it reaches a detector first (the reason why it is called primary). The P-waves also called compressional waves, travel by particles vibrating parallel to the direction the wave travel. They force the ground to move backward and forward as they are compressed and expanded. Most importantly, they travel through solids, liquids and gases.

The S-wave (secondary wave or shear wave) is a pulse energy that travels slower than a P-wave through Earth and solids. The S-waves move as shear or transverse waves, and force the ground to sway from side to side, in rolling motion that shakes the ground back and forth perpendicular to the direction of the waves. The idea that the S-waves cannot travel through any liquid medium led seismologists to conclude that the outer core is liquid. Figure 1 shows the vibration directions of P and S-waves.

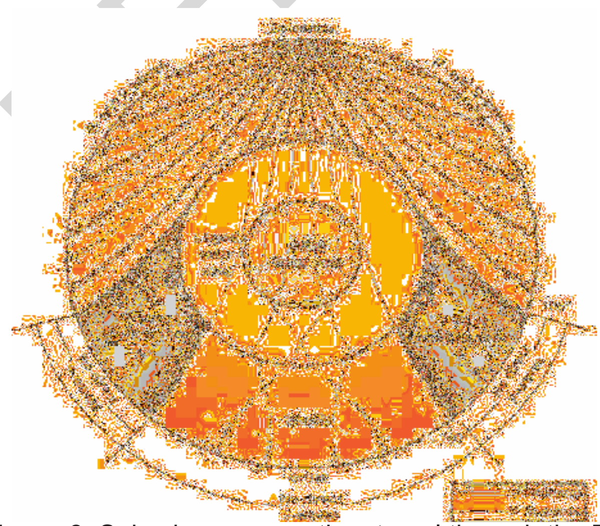


www.furuno.com

Figure 2. Body Waves

Scientists gained information about the Earth's internal structure by studying how seismic waves travel through the Earth. It involves measuring the time it takes for both types of waves to reach seismic wave detecting stations from the epicenter of an earthquake. An epicenter is a point in the Earth's surface directly above the focus. Since P-waves travel faster than S-waves, they're always detected first. The farther away from the epicenter means the longer time interval between the arrival of P and S waves.

In 1909, Yugoslavian seismologist Andrija Mohorovičić (moh-haw-roh-vuh-chich) found out that the velocity of seismic waves changes and increases at a distance of about 50 kilometers below the Earth's surface. This led to the idea that there is a difference in density between the Earth's outermost layer (crust) and the layer that lies below it (mantle). The boundary between these two layers is called Mohorovičić discontinuity in honor of Mohorovičić, and is short termed Moho.



P-waves can travel through liquids while S-waves cannot. During an earthquake, the seismic waves radiate from the focus. Based on figure on the right, the waves bend due to change in density of the medium. As the depth increases, the density also increases.

http://www.cyberphysics.co.uk/topics/earth/geophysics/Seismic%20Waves%20Reading.htm

Figure 3. Seismic waves as they travel through the Earth

P-waves are detected on the other side of the Earth opposite the focus. A shadow zone from 103° to 142° exists from P-waves as shown in Figure 3. Since P-waves are detected until 103°, disappear from 103° to 142°, then reappear again, something inside the Earth must be bending the P-waves. The existence of a shadow zone, according to German seismologist Beno Gutenberg (guː t ə n bɛʁk), could only be explained if the Earth contained a core composed of a material different from that of the mantle causing the bending of the P-waves. To honor him, mantle–core boundary is called Gutenberg discontinuity.

From the epicenter, S-waves are detected until 103°, from that point, S- waves are no longer detected. This observation tells us that the S-waves do not travel all throughout the Earth's body. There is a portion inside the Earth that does not conduct the propagation of S-wave. Hence, knowing the properties and characteristics of S-waves (that it cannot travel through liquids), and with the idea that P-waves are bent to some degree, this portion must be made of liquid, thus the outer core.

In 1936, the innermost layer of the Earth was predicted by Inge Lehmann, a Danish seismologist. He discovered a new region of seismic reflection within the core. So, the Earth has a core within a core. Based on Figure 3 on page 8, we can say that the outer part of the core is liquid based from the production of an S wave shadow and the inner part must be solid with a different density than the rest of the surrounding material.

The size of the inner core was accurately calculated through nuclear underground tests conducted in Nevada. Echoes from seismic waves provided accurate data in determining its size.

Table 1 shows the relative thickness of the different layers of the Earth.

Table 1. Thickness of the Different Layers of the Earth

Layer	Thickness in kilometers
Crust	40
Mantle	2900
Outer core	2200
Inner core	1278

Perform the following activity to test your understanding about seismic waves.

Activity 1

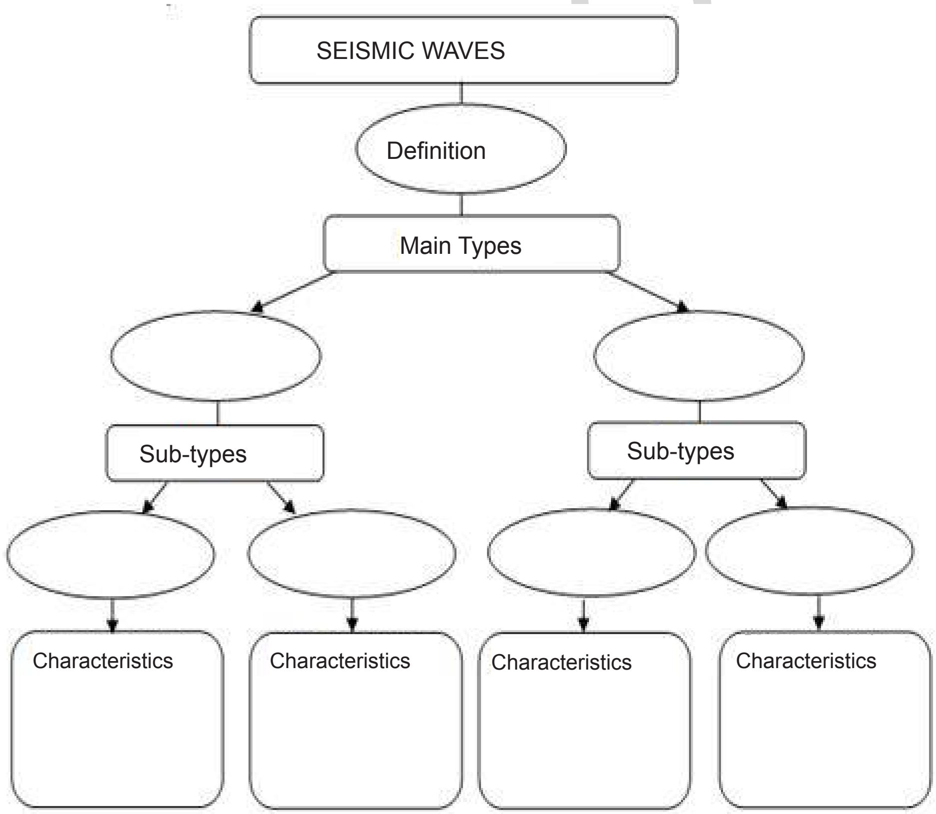
Amazing Waves!

Objectives:

- Define seismic waves scientifically.
- Differentiate the different types of seismic waves.
- Recognize the importance of seismic waves in the study of the Earth's interior.

Procedure:

Using the given organizer, write the necessary information to complete the concept about seismic waves.



Q1. Differentiate surface waves from body waves.

Q2. Which type of waves do you think were useful to seismologists in their study of the Earth's interior? Explain your answer.

The Composition of the Earth's Interior

The Earth's composition tells a story about itself. It gives us clues to its past and proofs about the gradual and slow changes that it has undergone for over 4.6 billion years.

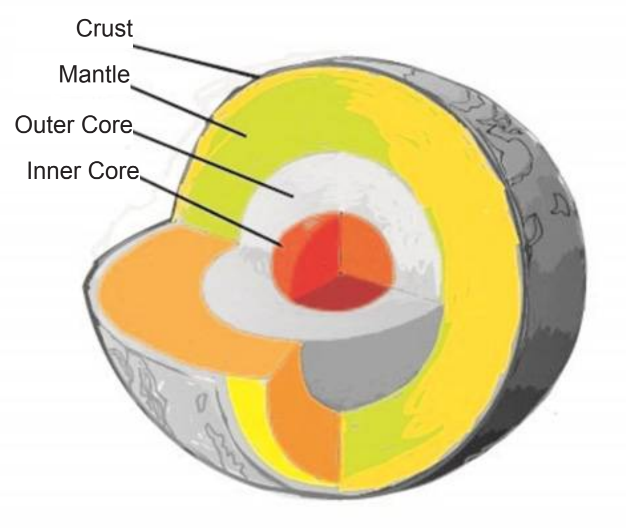
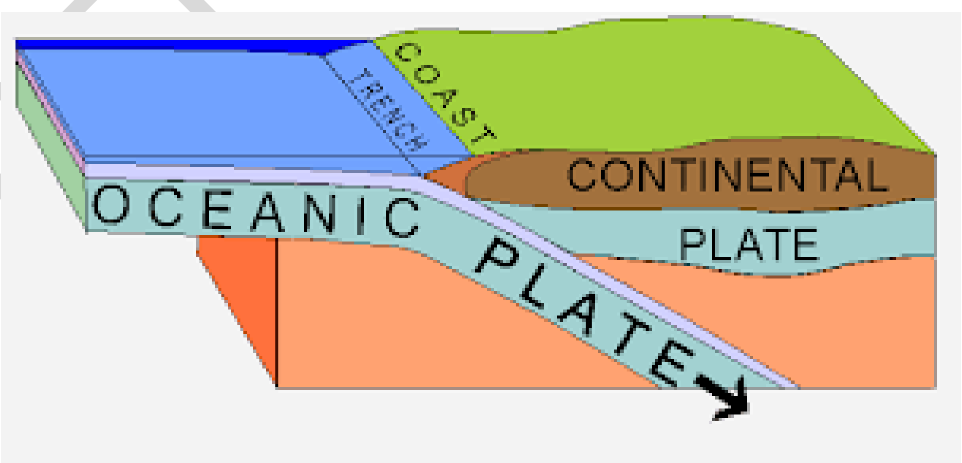


Figure 4. Earth's Cross Section

The Crust

The crust is the thinnest and the outermost layer of the Earth that extends from the surface to about 32 kilometers below. Underneath some mountains, the crust's thickness extends to 72 kilometers. The Earth's crust, as gleaned from Figure 5 on page 12, is subdivided into two regions: the continental crust and the oceanic crust.



https://mrb-science.wikispaces.com/Plate+Tectonics
Figure 5. The Continental and the Oceanic Crust

The continental crust is mainly made up of silicon, oxygen, aluminum, calcium, sodium, and potassium. The thickness of the continental crust is mostly 35-40 kilometers. Continental crust, found under land masses, is made of less dense rocks such as granite.

The oceanic crust is around 7-10 kilometers thick which its average thickness is 8 kilometers. It is found under the ocean floor and is made of dense rocks such as basalt. The oceanic crust is heavier than the continental crust.

The crust consists of two layers. The upper layer is composed of granite and is only found in the continental crust. Below the granite is a layer made mainly of basalt. This is found on both under the continents and the oceans.

Table 2 shows the different elements that compose the Earth's crust.

Table 2. Elements in the Earth's crust

Element	Percentage
Oxygen	46.60
Silicon	27.72
Aluminum	8.13
Iron	5.00
Calcium	3.63
Sodium	2.83
Potassium	2.59
Magnesium	2.09
Titanium	0.40
Hydrogen	0.14

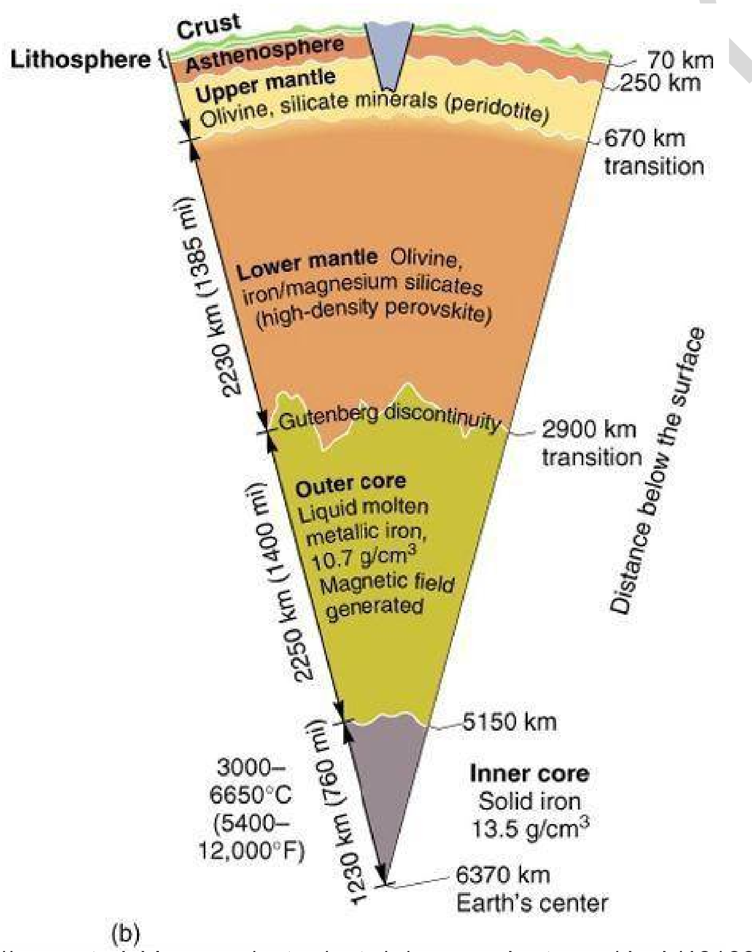
The Mantle

Beneath the crust is the mantle, which extends to about 2900 kilometers from the Earth's surface. It makes up about 80% of the Earth's total volume and about 68% of its total mass. The mantle is mainly made up of silicate rocks, and contrary to common belief, is solid, since both S-waves and P-waves pass through it.

The attempt to study the Earth's mantle extended as far as studying the rocks from volcanoes, simply because they were formed in the mantle. Scientists also studied rocks from the ocean floor. They have determined that the mantle is mostly made of the elements silicon, oxygen, iron and magnesium. The lower part of the mantle consists of more iron than the upper part. This explains that the lower mantle is denser than the upper portion. The temperature and the pressure increase with depth. The high temperature and pressure in the mantle allows the solid rock to flow slowly.

The crust and the uppermost part of the mantle form a relatively cool, outermost rigid shell called lithosphere and is about 50 to 100 kilometers thick. These lithospheric plates move relative to each other.

Beneath the lithosphere lies the soft, weak layer known as the asthenosphere, made of hot molten material. Its temperature is about 300 – 800°C. The upper 150 kilometers of the asthenosphere has a temperature enough to facilitate a small amount of melting, and make it capable to flow. This property of the asthenosphere facilitates the movement of the lithospheric plates. The lithosphere, with the continents on top of it, is being carried by the flowing asthenosphere.



https://www.studyblue.com/notes/note/n/geography-terms/deck/4616076

Figure 6. The Lithosphere and the Asthenosphere

The Core

The core is subdivided into two layers: the inner and the outer core. The outer core is 2900 kilometers below the Earth's surface. It is 2250 kilometers thick and is made up of iron and nickel. The temperature in the outer core reaches up to 2000°C at this very high temperature, iron and nickel melt.

Aside from seismic data analysis, the Earth's magnetic field strengthens the idea that the Earth's outer core is molten/liquid. The outer core is mainly made up of iron and nickel moving around the solid inner core, creating Earth's magnetism.

The inner core is made up of solid iron and nickel and has a radius of 1300 kilometers. Its temperature reaches to about 5000°C. The extreme temperature could have molten the iron and nickel but it is believed to have solidified as a result of pressure freezing, which is common to liquids subjected under tremendous pressure.

What tells us that the inner core is made up of iron?

Aside from the fact that the Earth has a magnetic field and that it must be iron or other materials which are magnetic in nature, the inner core must have a density that is about 14 times that of water. Average crustal rocks with densities 2.8 times that of water could not have the density calculated for the core. So iron, which is three times denser than crustal rocks, meets the required density.

Some clues that the inner core and the outer core are made up of iron include the following:

- Iron and nickel are both dense and magnetic.
- The overall density of the earth is much higher than the density of the rocks in the crust. This suggests that the inside must be made up of something denser than rocks.
- Meteorite analysis have revealed that the most common type is chondrite. Chondrite contains iron, silicon, magnesium and oxygen; some contains nickel. The whole earth and the meteorite roughly have the same density, thus the Earth's mantle rock and a meteorite minus its iron, have the same density.

Activity 2

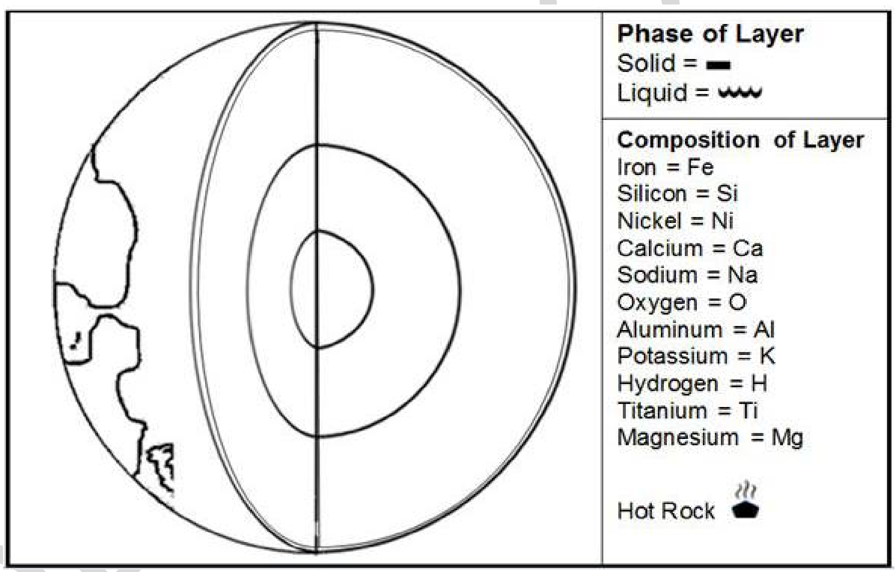
Our Dynamic Earth

Objectives:

- Describe the properties of the layers of the Earth.
- Tell the composition of the layers of the Earth.

Procedure:

1. Label the drawing corresponding to the Earth's layers.
2. Describe the different layers of the Earth using symbols.
3. Choose from the response grid on the right the symbol that you need to finish the figure on the left.
4. Draw the symbol/s in the corresponding layer of the Earth.



Guide Questions:

Q3. What element is the most abundant in the Earth's crust?

Q4. What elements make up most of the mantle?

Q5. What is the special feature of the upper mantle?

Q6. How did scientists come to know that the outer core is liquid?

Q7. What materials make up the inner core?

Q8. Is the inner core solid, liquid, or gas? What keeps it in this phase?

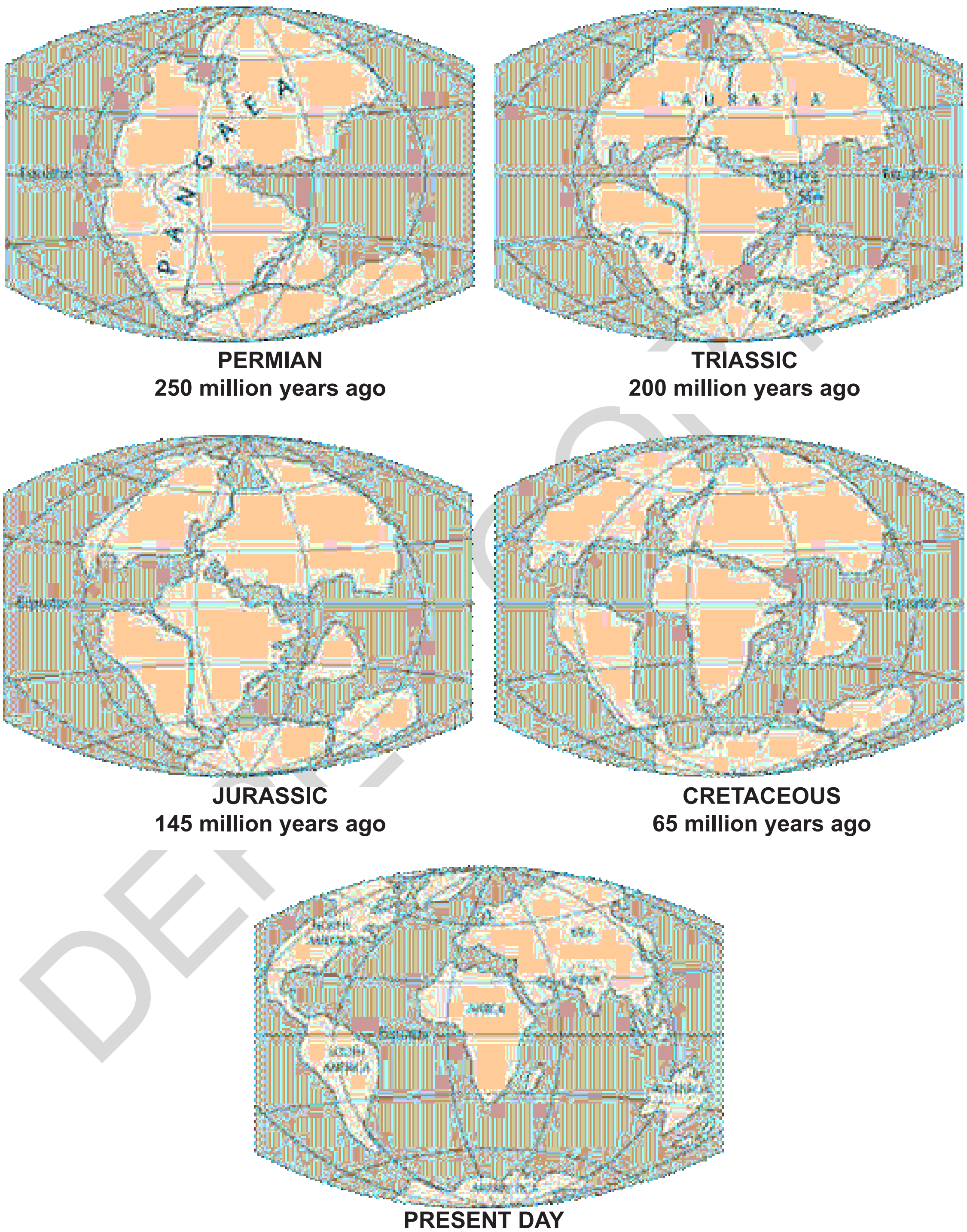
Q9. Compare the inner core and the outer core.

The Earth's Mechanism

The Continental Drift

Have you had the chance to go to a mountain, stand on its peak and look at the beauty that it offers? Do you think it looks exactly the same as before? Perhaps you would think that it might be different - all plain, no plateaus, no mountains. If it wasn't the same 10 years ago, how much different is it 10 million years ago, 100 million years ago?

In 1912, Alfred Wegener (pronounced as vey-guh-nuh r), a German meteorologist, proposed a theory that about 200 million years ago, the continents were once one large landmass. He called this landmass Pangaea, a Greek word which means "All Earth." Figure 7 shows how Pangaea evolved into how the continents look today. This Pangaea started to break into two smaller supercontinent called Laurasia and Gondwanaland during the Jurassic Period. These smaller supercontinents broke into the continents and these continents separated and drifted apart since then. Is this idea somehow true? If you lived during Wegener's time, will you believe him?



pubs.usgs.gov
Figure 7. The Evolution of Pangaea

Wegener searched for evidences to support his claim. He noticed the fit of the edges of the continents on the opposite sides of the South Atlantic. His evidences to the Continental Drift Theory includes the distribution of fossils in different continents, rock features, and ancient climates. Let us have a further study on these evidences.

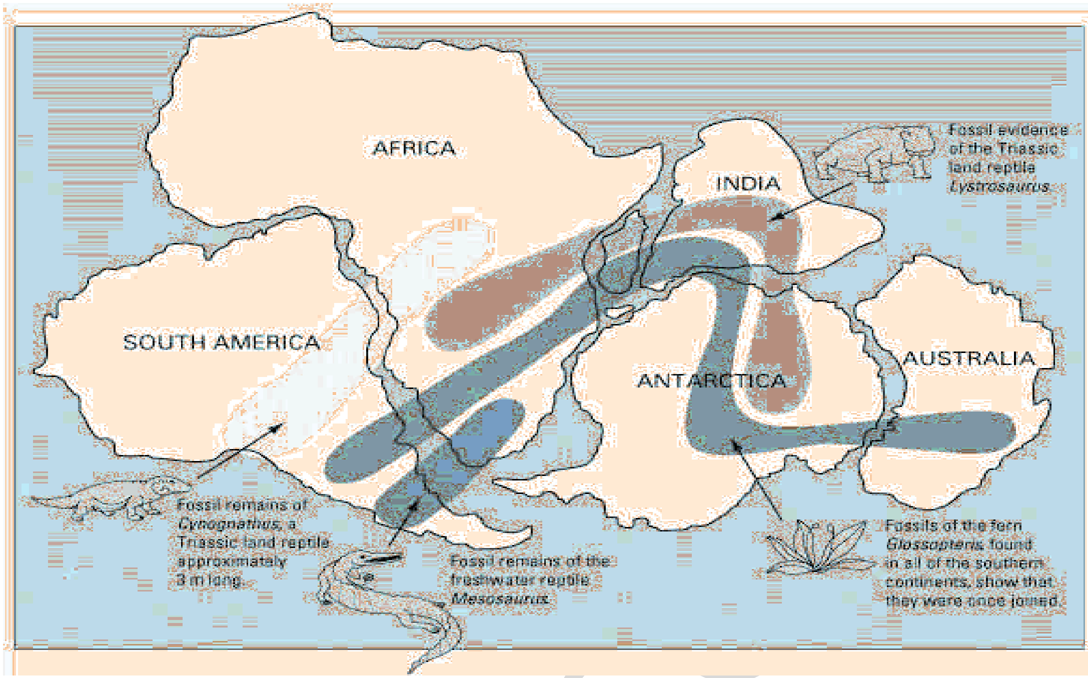
Evidence: The Continental Jigsaw Puzzle

Did it really start as one big landmass? It seems very impossible that the seven continents, which are currently thousands of miles away from each other were actually connected pieces of a supercontinent.

The most visible and fascinating evidence that these continents were once one is their shapes. The edge of one continent surprisingly matches the edge of another: South America and Africa fit together; India, Antarctica, and Australia match one another; Eurasia and North America complete the whole continental puzzle in the north.

Evidence from Fossils

Fossils are preserved remains or traces of organisms (plants and animals) from the remote past. Fossilized leaves of an extinct plant *Glossopteris* were found in 250 million years old rocks. These fossils were located in the continents of Southern Africa, Australia, India, and Antarctica, which are now separated from each other by wide oceans. The large seeds of this plant could not possibly travel a long journey by the wind or survive a rough ride through ocean waves.



Source: http://pubs.usgs.gov/gip/dynamic/continents.html
Figure 8. Distribution of Fossils across Different Continents

Source: fossilmall.com
Figure 9. *Glossopteris* Fossil

Mesosaurus (shown in Figure 10) and *Lystosaurus* are freshwater reptiles. Fossils of these animals were discovered in different continents, such as in South America and Africa. It is impossible for these reptiles to swim over the vast oceans and move from one continent to another. Fossils were also found in Antarctica. Could it be possible that they existed in this region where temperature was very low? Or could it be possible that, long before, Antarctica was not in its current position?

Source: www.busacagallery.com
Figure 10. *Mesosaurus* Fossil

The following activities will give you an idea how the Continental Drift Theory was conceived.

Activity 3

Let's Fit it!

Objectives:

- Find clues to solve a problem.
- Recognize how the Continental Drift Theory is developed.

Materials:

- old newspaper or magazine
- scotch tape

Procedure:

1. Do this activity in a group of five to six members.
2. Obtain a set of torn newspaper page or magazine page from your teacher.
3. Try to fit the pieces together.
4. Use a tape to connect the pieces.

   Q10. What features of the newspaper helped you to connect the pieces perfectly?

   Q11. How do the lines of prints or texts in the newspaper help you to confirm that you have reassembled the newspaper/magazine page?

   Q12. Show proofs that the newspaper is perfectly reassembled.

Activity 4

Drifted Supercontinent!

Objectives:

- Tell the possible direction of motion of the continents as they drifted away.
- Draw fossils of plants and animals as evidences found in the present continents that will help solve the puzzle in the fitting of the drifted continents.
- Reconstruct and describe Pangaea.
- Predict what will happen to the world as the continents continuously move.

Materials:

- photocopy of the seven continents
- world map
- pair of scissors

Procedure:

1. Cut carefully the traces of the seven continents. Warning: Be careful in using the scissors.

2. Sketch the dominant species of plants and animals found in the continents before and after drifting away from each other.

3. Put the cut-outs together.

   Q13. What do the Glossopteris fossils tell us about the early positions of the continents?

   Q14. If Glossopteris fossils were found in Antarctica, what was the climate of this continent before?

   Q15. If the climate and the position of a place are relative to each other, where then was the initial location of Antarctica 250 million years ago?

   Q16. What does the presence of Mesosaurus fossils tell about the initial location and positioning of South America, Africa, and Antarctica?

4. Make sure that you put fitting edges of the continents side by side to form the supercontinent Pangaea.

   Q17. What clues are useful in reconstructing Pangaea?

   Q18. Which continents do you think were neighbors before?

   Q19. Is there a possibility that the current location of a continent would be different 100 years from now?

   Q20. Where do you think was the Philippines located during the time that the Pangaea existed? Research on how the Philippine islands emerged.

5. Compare Pangaea with the world map.

6. Now move one continent relative to its current location. Observe carefully the direction of its motion as it assumes its current location and position. Record your observation.

7. Do the same procedure to the other continents. Record your observations.

   Q21. If the continents will continue to move, try to predict the Philippines' location 100 million years from now.

Evidence from Rocks

Fossils found in rocks support the Continental Drift Theory. The rocks themselves also provide evidence that continents drifted apart from each other. From the previous activity, you have learned that Africa fits South America. Rock formations in Africa line up with that in South America as if it was a long mountain range.

How come these rock layers in different continents line up together with layers that exactly matched?

The folded cape mountains of South America and Africa line up perfectly as if they were once a long mountain range.

Coal Deposits

Coal beds were formed from the compaction and decomposition of swamp plants that lived million years ago. These were discovered in South America, Africa, Indian subcontinent, Southeast Asia, and even in Antarctica. How is a coal bed formation possible in Antarctica?

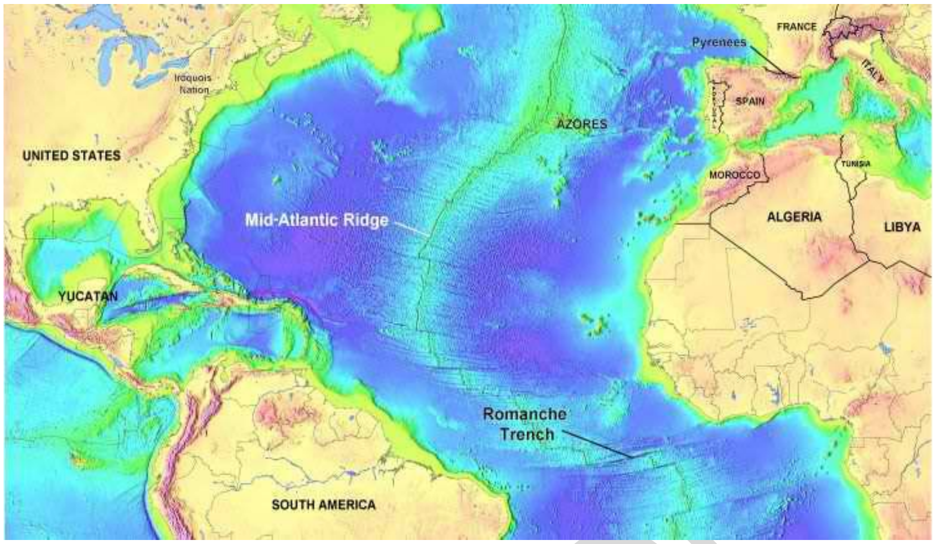
The current location of Antarctica could not sustain substantial amount of life. If there is a substantial quantity of coal in it, thus, it only means that Antarctica must have been positioned in a part of the Earth where it once supported large quantities of life. This leads to the idea that Antarctica once experienced a tropical climate, thus, it might have been closer before to the equator.

The Seafloor Spreading

The question as to how the drifting took place left the Continental Drift Theory blurry. Despite the evidences presented by Wegener, his idea that the continents were once joined together was not accepted by the scientific society until the 1960s. He wasn't able to explain how this drifting took place. This made scientists conduct further studies in search for the answer.

During the 1950s and 1960s, new techniques and modern gadgets enabled scientists to make better observations and gather new information about the ocean floor. With the use of sonars and submersibles, scientists had a clearer view of the ocean floors. They have discovered underwater features deep within the ocean.

Scientists found a system of ridges or mountains in the seafloor similar to those found in the continents. These are called mid-ocean ridges. One of these is the famous Mid-Atlantic Ridge (Figure 11), an undersea mountain chain in the Atlantic Ocean. It has a gigantic cleft about 32-48 km long and 1.6 km deep. The ridge is offset by fracture zones or rift valleys.



Source: huttoncommentaries.com
Figure 11. The Mid-Atlantic Ridge

In the early 1960's, scientist Harry Hess, together with Robert Dietz, suggested an explanation to the continental drift. This is the Seafloor Spreading Theory. According to this theory, hot, less dense material from below the earth's crust rises towards the surface at the mid-ocean ridge. This material flows sideways carrying the seafloor away from the ridge, and creates a crack in the crust. The magma flows out of the crack, cools down and becomes the new seafloor.

Overtime, the new oceanic crust pushed the old oceanic crust far from the ridge. The process of seafloor spreading allowed the creation of new bodies of water. For example, the Red Sea was created as the African plate and the Arabian plate moved away from each other. Seafloor spreading is also pulling the continents of Australia, South America, and Antarctica away from each other in the East Pacific Rise. The East Pacific Rise is one of the most active sites of seafloor spreading, with more than 14 centimeters every year.

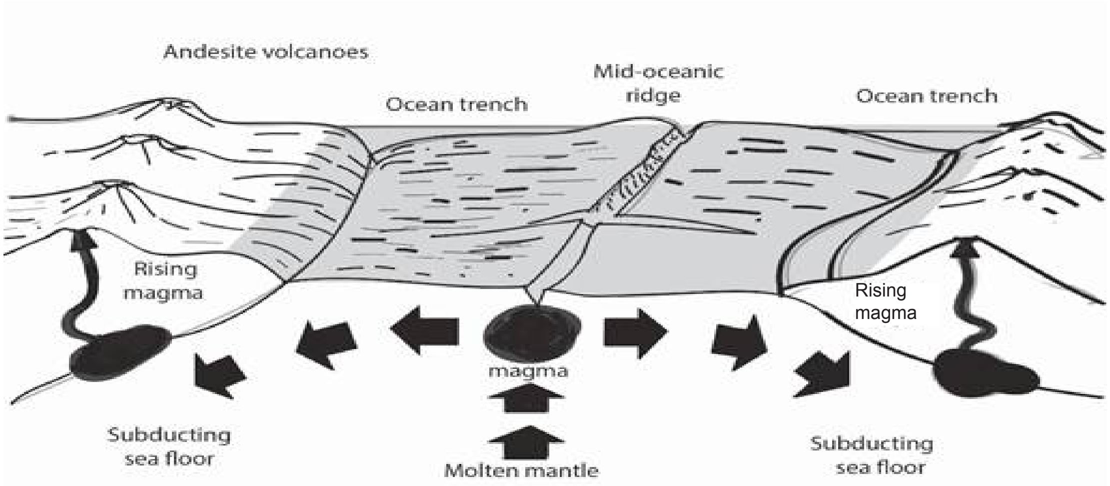


Figure 12. Diagram of Seafloor Spreading

In the place where two oceanic plates collide or where an oceanic plate and a continental plate collide, a subduction zone occurs. As the new seafloor is formed at the mid-ocean ridge, the old seafloor farthest from the ridge is destroyed at the subduction zone.

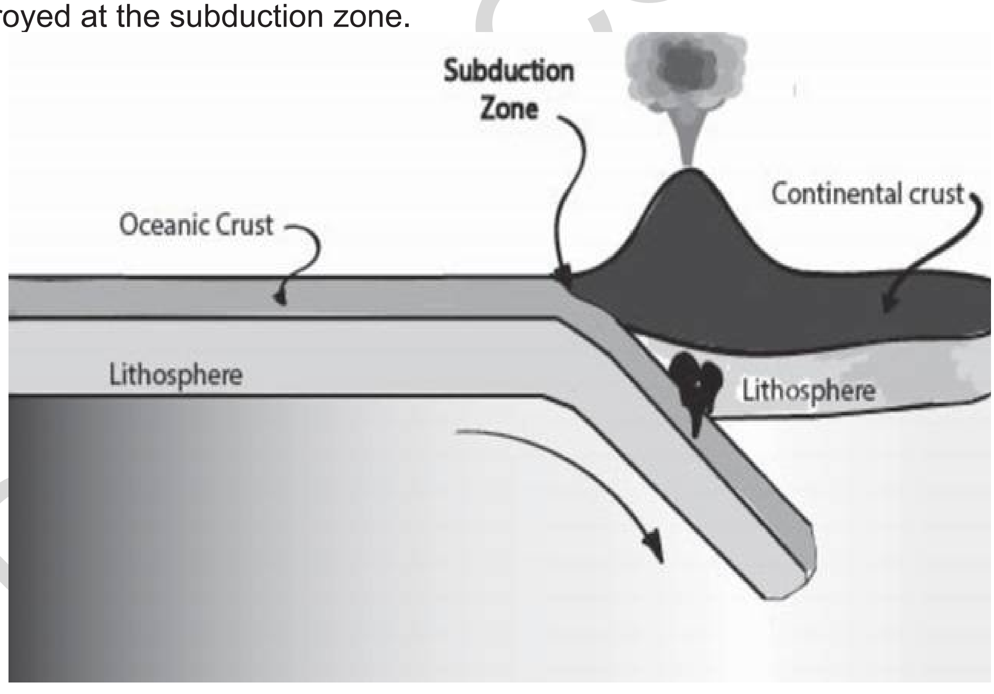


Figure 13. Subduction Zone

The rate of formation of a new seafloor is not always as fast as the destruction of the old seafloor at the subduction zone. This explains why the Pacific Ocean is getting smaller and why the Atlantic Ocean is getting wider. If subduction is faster than seafloor spreading, the ocean shrinks. When the seafloor spreading is greater than the subduction, then the ocean gets wider.

Findings that support Seafloor Spreading Theory:

1. Rocks are younger at the mid-ocean ridge.
2. Rocks far from the mid-ocean ridge are older.
3. Sediments are thinner at the ridge.
4. Rocks at the ocean floor are younger than those at the continents.

The Seafloor Spreading Theory contradicts a part of the Continental Drift Theory. According to this theory, continents moved through unmoving oceans and that larger, sturdier continents broke through the oceanic crust. Whereas, the seafloor spreading shows that the ocean is the actual site of tectonic activity.

Magnetic Reversal

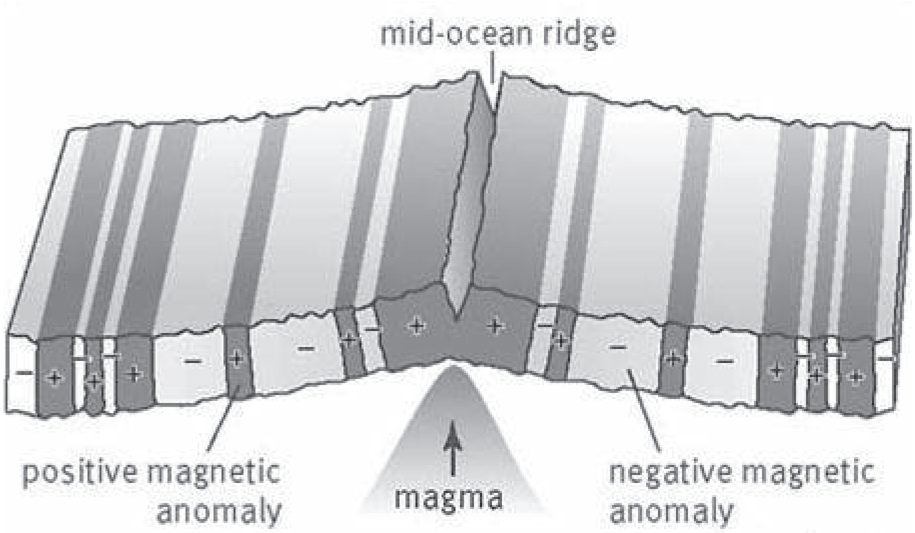
Seafloor spreading was strengthened with the discovery that the magnetic rocks near the ridge follow a pattern aside from the fact that rocks near the ridge are remarkably younger than those father from the ridge.

A magnetic compass tells us directions on Earth. It also proves that the Earth has a magnetic field. The needle of a magnetic compass usually points to the North Pole of the Earth which is actually the South Magnetic Pole at present.

The Earth's magnetic field is generated in the very hot molten outer core and has already existed since the birth of our planet. The Earth's magnetic field is a dipole, one that has a North Pole and a South Pole.

What is magnetic reversal? How does magnetic reversal happen and how does it prove seafloor spreading? Magnetic reversal is also called magnetic 'flip' of the Earth. It happens when the North Pole is transformed into a South Pole and the South Pole becomes the North Pole. This is due to the change in the direction of flow in the outer core.

Magnetic reversals happened many times in the past. The occurrence of magnetic reversals can be explained through the magnetic patterns in magnetic rocks, especially those found in the ocean floor. When lava solidifies, iron bearing minerals crystallize. As these crystallize, the minerals behave like tiny compasses and align with the Earth's magnetic field. So when magnetic reversal occurs, there is also a change in the polarity of the rocks. This allowed scientists to visualize the magnetic stripes in the ocean floor similar to Figure 14, and to construct a magnetic polarity time scale similar to Figure 15.



http://www.yourdictionary.com/magnetic-reversal

Figure 14. Magnetic Reversal

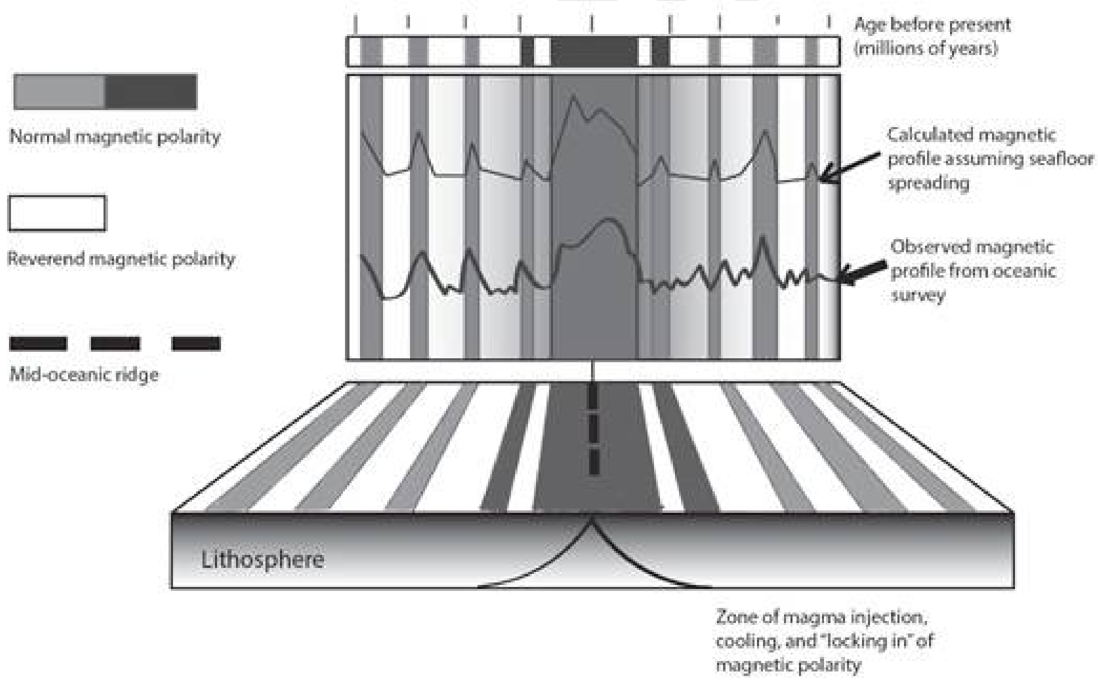


Figure 15. Magnetic Polarity Time Scale

Over the last 10 million years, there has been an average of 4 to 5 reversals per million years. New rocks are added to the ocean floor at the ridge with approximately equal amounts on both sides of the oceanic ridge. The stripes on both sides are of equal size and polarity which seemed to be mirror images across the ocean ridge. What does this indicate? It indicates that indeed, the seafloor is spreading.

Try the following activity to further explore what happens deep under the ocean at the Mid-Atlantic Ridge.

Activity 5

Split and Separate!

(Adapted)

Objectives:

- Simulate and describe the seafloor spreading process.
- Realize the importance of the seafloor spreading process relative to the Continental Drift Theory.

Materials:

- board paper
- bond paper
- colored pencil
- pair of scissors
- ruler

Procedure:

1. Using a colored pencil, draw stripes across one sheet of bond paper parallel to the short sides of the paper. The stripes should vary in spacing and thickness.
2. Fold the bond paper in half lengthwise.
3. Write the word "*Start*" at the top of both halves of the paper. It should look like the figure on the right.
4. Cut the bond paper in half along the dashed line to form two strips.
5. Take the board paper and make three (3) 11-cm long slits as indicated in the illustration.

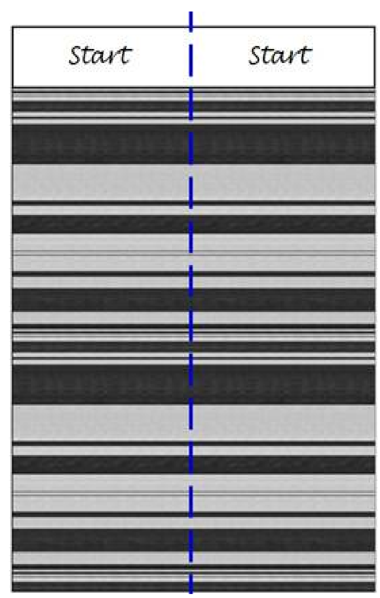
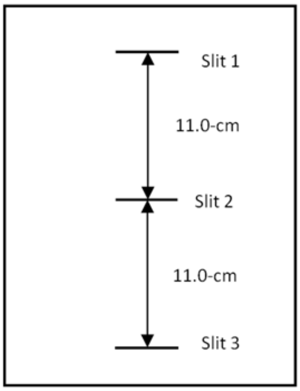


Illustration 1. Bond Paper

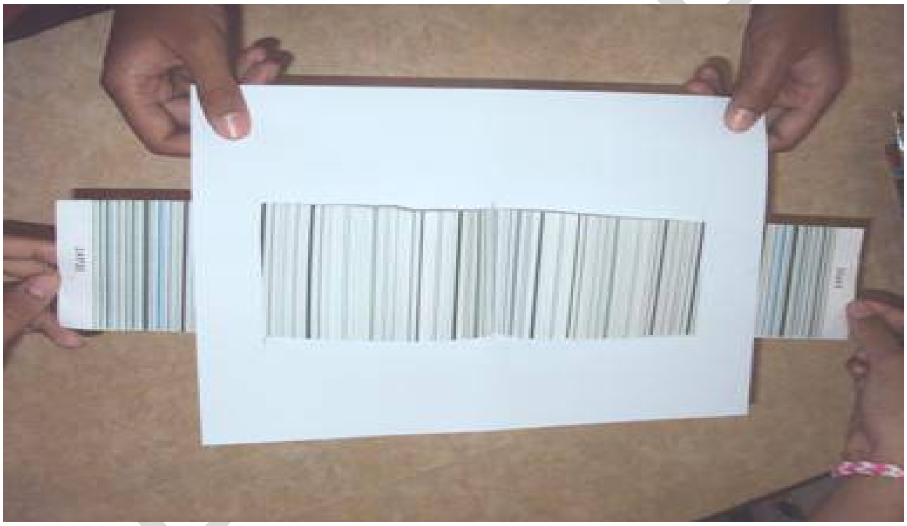
6. The two slits near the edges of the bond paper should be both 11-cm from the center slit.



7. Put the two striped strips of paper together so that the “Start” labels touch one another.

8. Insert the strips up through the center slit, then pull them toward the side slits.

9. Insert the ends of the strips into the side slits. Pull the ends of the strips as shown in the figure below and watch what happens at the center slit.



10. Practice pulling the strips through the slits until you can make the stripes come up and go down at the same time.

Q22. What do the stripes in the paper represent?

Q23. What does the middle slit represent? What occurs in this region?

Q24. What is the role of the mid–ocean ridge in the movement of lithospheric plates?

Q25. How does the new seafloor form at the mid-ocean ridge?

Q26. What process/es happen at the side slits?

Q27. Is the earth getting larger and wider when plates drift away from each other? Explain briefly.

Now that you understand the Seafloor Spreading Theory, try the following activity to find how fast the seafloor is spreading.

Activity 6

How fast does it go!

Adapted (Glencoe Earth Science student edition copyright 2002)

Objectives:

- Analyze a magnetic polarity map.
- Use legends and scales of the map properly.
- Calculate the rate of seafloor spreading using magnetic clues.

Materials:

- magnetic polarity map
- metric ruler
- pencil

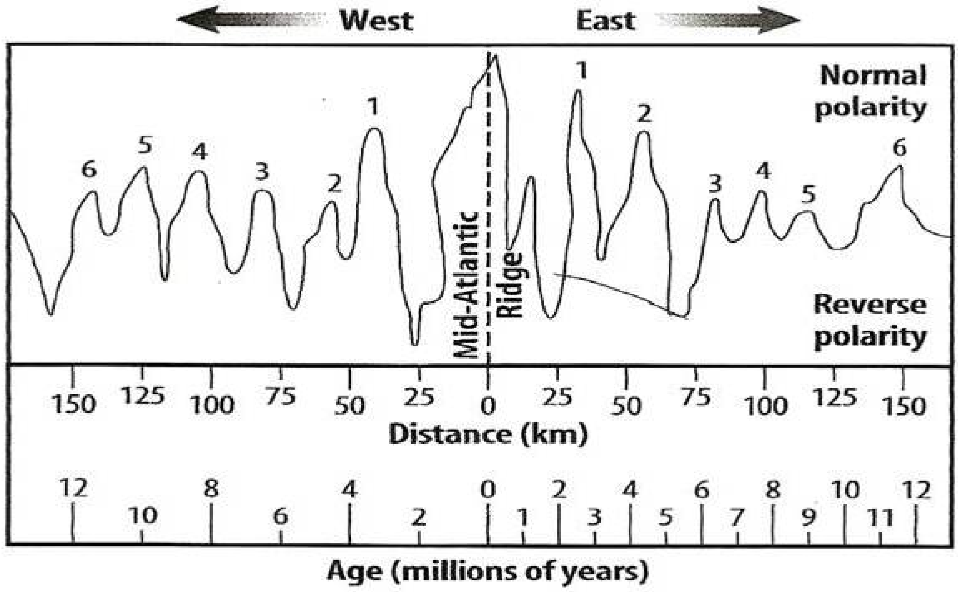
Procedure:

1. Study the magnetic polarity map. You will be working only with normal polarity readings, these are the peaks above the baseline on the top half of the graph.

2. Place the long edge of the ruler vertically on the graph. Align the ruler with the center peak 1 of the Mid-Atlantic Ridge.

3. Determine and record the distance and age that line up with the center of peak 1 west. Repeat this process for peak 1 east of the ridge.

4. Calculate the average age and distance for this pair of peaks.



Magnetic polarity map

5. Repeat steps 2 to 4 for the remaining pairs of normal polarity peaks.

6. Calculate the rate of movement in centimeters per year using the formula
   Rate = distance / time.

   Q28. How far do the plates move away from each other every year?

   Q29. If Africa is approximately 2400 km away from the Mid-Atlantic Ridge, how long ago was it when Africa was directly at or near the Mid-Atlantic Ridge?

Plate Tectonic Theory

What causes tectonic plates to move? This is one of the main questions that has remained unanswered since Alfred Wegener proposed the Continental Drift Theory.

The Plate Tectonic Theory provided an explanation about the movement of the lithospheric plates. This theory evolved from the two former theories and was developed during the first decades of the 20th century.

The Earth's lithosphere is divided into several plates. As you have already learned, these plates ride over the weak asthenosphere. There are three types of plate movements – separation of two plates (divergent), collision of two plates (convergent) and sliding past each other (transform).

What facilitates the movement of the plates? Heat is produced in the core that produces convection in the mantle. This convection causes the plate to move around. To further understand this process, try the following activity.

Activity 7

Push me up and aside!

(Adapted)

Objectives:

- Explain what causes the tectonic plates to move.
- Enumerate the factors that cause tectonic plates to move.
- Realize the importance of the creation of convection current underneath the earth.

Materials:

- dropper
- food color
- 1000 mL beaker
- 700 mL water
- 3-5 small / light wood blocks
- hotplate/alcohol burner & tripod

Procedure:

1. Pour 700 mL of water into the beaker.

2. Place the beaker on a hotplate and heat it. Give ample time for the water to heat up.

   Warning: Make sure that you know how to operate a hotplate.
   Wear heat resistant gloves to protect your hands.
   In the absence of a hotplate, you can use an alcohol burner.

3. Add a few drops of food coloring to the water in the beaker.

4. Looking from the side of the dish, observe what happens in the water.

   Q30. How does the food coloring behave?

Q31. What do you call this behavior?

Q32. Enumerate the factors that cause the formation of a current.

5. Put several light wood blocks in the center of the heated near to boiling water.

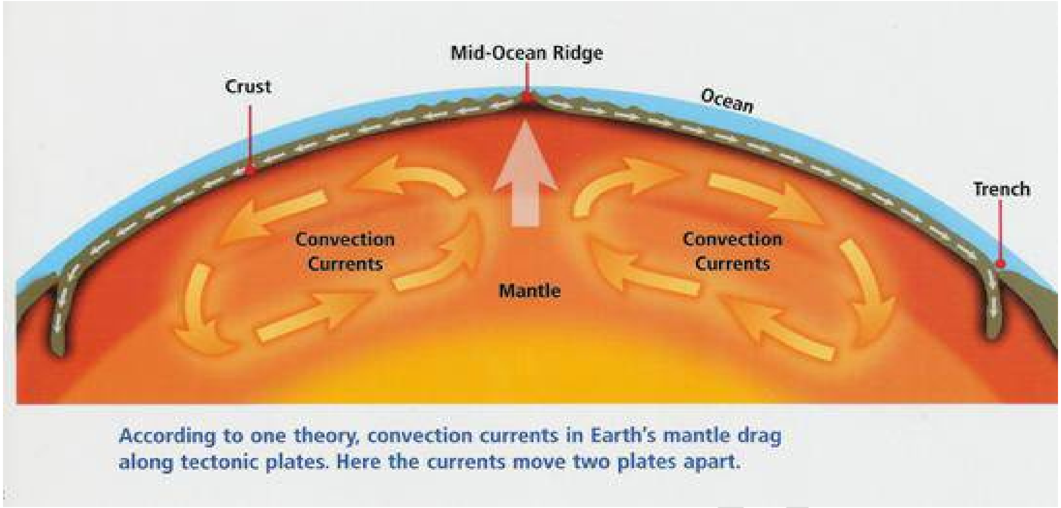
   Q33. What happens to the blocks? What does this resemble?

6. Illustrate your observations.

Convection Current

As a substance like water is heated, the less dense particles rise while denser particles sink. Once the hot less dense particles cool down, they sink, and the other less dense particles rise. This continuous process is called convection current. This is exactly what happens in the Earth's mantle. The hot, less dense rising material spreads out as it reaches the upper mantle causing upward and sideward forces. These forces lift and split the lithosphere at divergent plate boundaries. The hot magma flows out of the mantle and cools down to form the new ocean crust. The downward movement of the convection current occurs along a convergent boundary where the sinking force pulls the tectonic plate downward.

The convection currents rotate very slowly, as they move and drag the plates along. Because of convection current, the tectonic plates are able to move slowly along the tectonic boundaries, pushing each other, sliding past each other and drifting away from each other. This process is further illustrated in Figure 16 below.



Source: www2.chilton.k12.wi.us

Figure 16. Convection Current in the Mantle

As an oceanic crust moves away from a divergent boundary, it becomes denser than the newer oceanic crust. As the older seafloor sinks, the weight of the uplifted ridge pushes the oceanic crust toward the trench at the subduction zone. This process is called ridge push.

Slab pull is the other possible process involved in the tectonic plate movement. The weight of the subducting plate pulls the trailing slab into the subduction zone just like a tablecloth slipping off the table and pulling items with it.

Now that you understand what happens inside the Earth and its effects on the Earth's surface, you should be able to realize that the tectonic activities at the surface just like volcanic eruptions and earthquakes are inevitable. You should view the Earth as a dynamic planet and still the most fascinating planet for it offers you a home that no other planet can. Since you can't prevent these tectonic activities from happening, the following performance task will enable you to contribute meaningfully in minimizing the damage that these phenomena can bring.

Performance Task

Goal

To design a scheme to inform local folks in your hometown about the possibilities of earthquakes, tsunami, and other geologic activities in your area

Role

A project engineer who wants to develop a new subdivision, a realtor who sells a house & lot, a geologist visiting his/her hometown or simply a student seeking to help the government.

Audience

People in your locality

Situation

You are to inform local folks in your hometown about the possibilities of earthquakes, tsunami, and other geologic activities in your area. Most especially, you must bring out in them the sense of being always ready and prepared.

Product

Informative materials about ways to mitigate the effects of tectonic activities-related disasters

Standards

You will be rated according to the following criteria:

Details and Information	4 points
Method of Presentation/Dissemination	4 points
Techniques	4 points
Accuracy	4 points
Feedback/Result	4 points
TOTAL	**20 points**

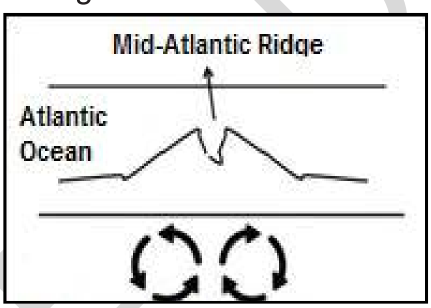
V. Summative Assessment

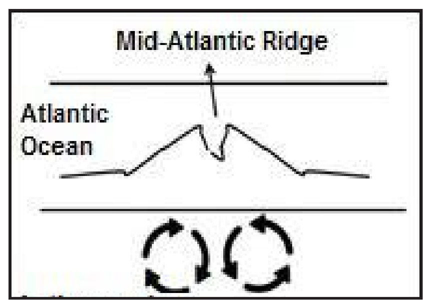
Answer the following questions.

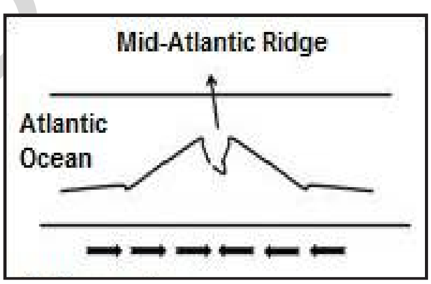
1. In 1912, Alfred Wegener proposed a theory that the Earth is once a single landmass. What is the name of the Mesozoic supercontinent that consisted of all of the present continents?
   a. Eurasia
   b. Laurasia
   c. Pangaea
   d. Gondwanaland

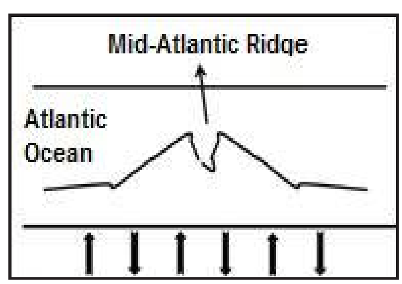
2. Who were the two scientists who proposed the theory of seafloor spreading in the early 1960s?
   a. Charles Darwin and James Hutton
   b. Harry Hess and Robert Dietz
   c. John Butler and Arthur Smite
   d. F. Vine and D. Mathews

3. Which of the following diagrams best illustrates the convection occurring in the mantle?

a.


c.


b.


d.


4. During the 1960s, scientists were already equipped with gadgets needed to explore the deep ocean. What discovery about the ocean floor is associated with the seafloor spreading?
   a. Mountains are denser than the mantle.
   b. The rotational poles of the Earth have migrated.
   c. The crust of the continents is more dense than the crust of the ocean.
   d. The crust of the ocean is very young relative to the age of the crust of the continents.

5. If the Atlantic Ocean is widening at a rate of 3 cm per year, how far (in kilometers) will it spread in a million years?
   a. 3 kilometers
   b. 30 kilometers
   c. 300 kilometers
   d. 3000 kilometers

6. Which of the following increases with distance from a mid-ocean ridge?
   a. the age of oceanic lithosphere
   b. the thickness of the lithosphere
   c. the depth to the sea floor
   d. all of the above

7. Which of the following can you infer from the continuous movement of the lithospheric plates over the asthenosphere?
   a. All the continents will cease to exist.
   b. All the volcanoes in the Philippines will become inactive.
   c. The continents will not be located in the same place as they are now.
   d. The islands of the Philippines will become scattered all over the world.

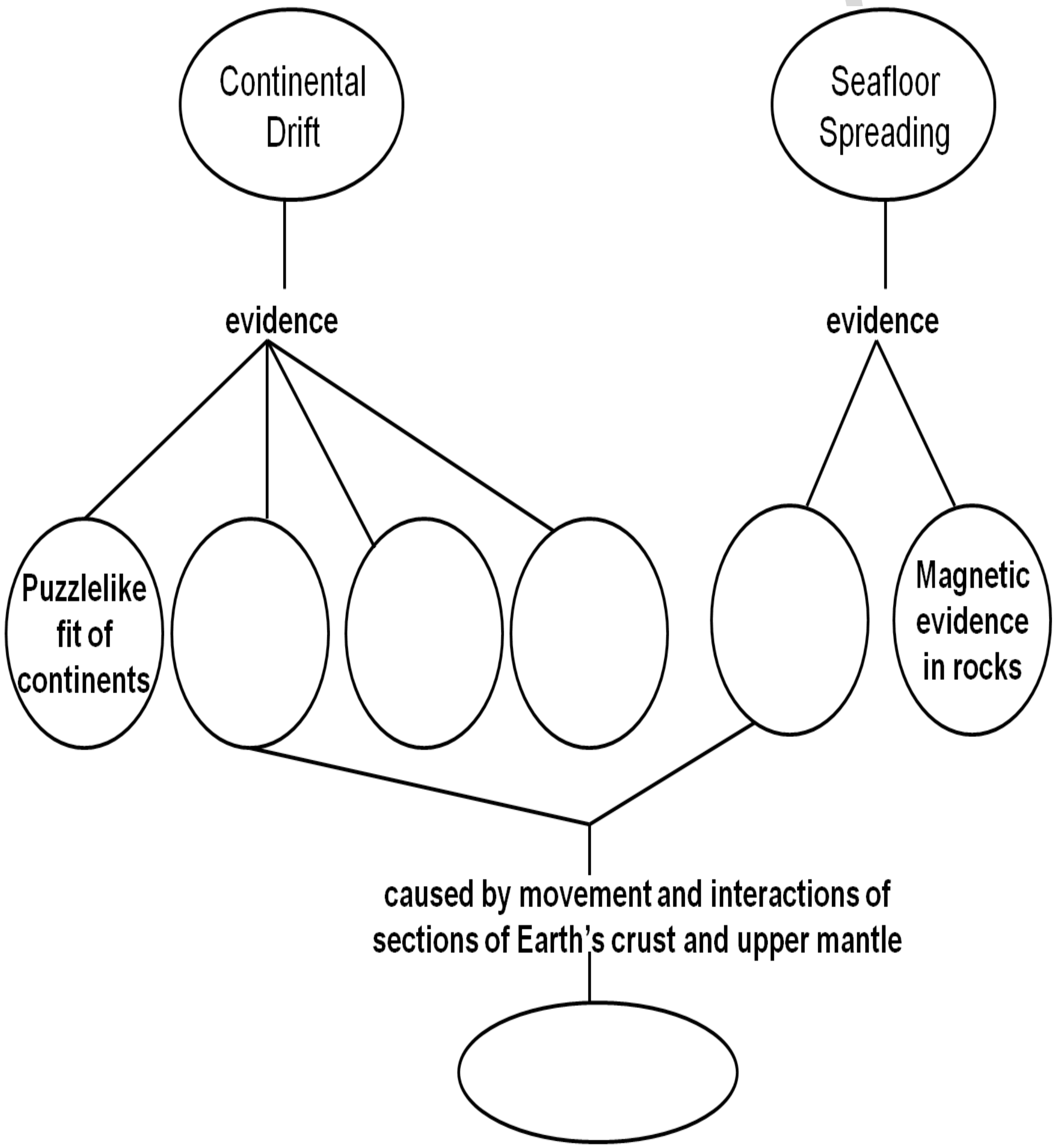
8. If all the inner layers of the Earth are firm solid, what could have happened to Pangaea?
   a. It remained as a supercontinent.
   b. It would have become as it is today.
   c. It would have slowly disappeared in the ocean.
   d. It would have stretched and covered the whole world.

9. Why does the oceanic crust sink beneath the continental crust at the subduction zone?
   a. The oceanic crust has a greater density.
   b. The oceanic crust is pulled downward by Earth's magnetic field.
   c. The oceanic crust is pushed from the ridge.
   d. The continental crust has a denser composition.

10. The lithospheric plates are believed to be moving slowly. What is the driving force that facilitates this movement?

    a. gravitational force of the moon
    b. magnetic force at the poles
    c. convection current in the mantle
    d. the force of the atmosphere

B. Complete the concept map below about continental drift, seafloor spreading, and plate tectonics.



VI. Summary/Synthesis/Feedback

- The Earth is composed of three major layers: the crust, mantle, and core which is subdivided into outer and inner core.
- The crust is the outermost and thinnest layer of the Earth.
- The mantle is the middle layer of the Earth. It makes most of the Earth's volume and mass.
- The crust and a part of the upper mantle make up the lithosphere. The lithosphere is subdivided into portions called lithospheric plates.
- The asthenosphere is the weak layer of the mantle on which the lithosphere floats.
- The outer core is made up of molten material and accounts for the Earth's magnetic field.
- The inner core is the deepest layer of the Earth. It is made up of solid nickel and iron. The temperature in the inner core reaches as high as 5000°C.
- The speed, reflection and refraction properties of seismic waves are used by scientists to study the structure and composition of the Earth's interior.
- The Continental Drift Theory of Alfred Wegener states that the continents were once part of a large landmass called Pangaea which drifted away from each other. The continents moved away from each other towards their current positions.
- Alfred Wegener based his theory on evidences from fossils imbedded in rocks and rock formations.
- Seafloor spreading is believed to occur as hot magma rises at the rift in the mid-ocean ridge. This magma cools down and becomes the new seafloor as it pushes the former.
- The old seafloor is destroyed at the subduction zone and melts inside the mantle.
- The age of rocks and the magnetic stripes in the ocean floor support the Seafloor Spreading Theory.
- The Theory of Plate Tectonics helps explain the formation and destruction of the Earth's crust and its movement over time.
- Scientists believe that the plates' movement is due to convection currents in the mantle.

Glossary of Terms

Asthenosphere – soft, weak upper portion of the mantle where the lithospheric plates float and move around

Continental Drift Theory – states that all the continents were once one large landmass that broke apart, and where the pieces moved slowly to their current locations

Convection current – current in the mantle because of the heat from the inner layers of the Earth, and is the force that drives the plates to move around

Lithosphere – the topmost, solid part of the Earth that is composed of several plates

Lithospheric Plates – the moving, irregularly-shaped slabs that fit together to form the surface of the Earth

Mid-ocean ridge – area in the middle of the ocean where a new ocean floor is formed when lava erupts through the cracks in the Earth's crust

Mohorovičić Discontinuity (Moho) – the boundary that separates the crust and the mantle

Plasticity – the ability of solid to flow

Seafloor spreading – process by which new ocean floor is formed near the mid-ocean ridge and moves outward

Subduction – the process in which the crust plunges back into the Earth

Tectonics – branch of geology that deals with the movements that shape the Earth's crust

References and Links

Printed Materials:

Borrero, Francisco *et al*. (2008). *Earth Science: Geology, the Environment, and the Universe.* The McGraw-Hill Companies, Inc.

Department of Education, Bureau of Secondary Education. Project EASE Integrated Science 1, Module 12: Inside the Solid Earth

Department of Education, Bureau of Secondary Education (2013). *Science – Grade 8 Learner's Module.* Vibal Publishing House, Inc.

Feather Jr.,Ralph *et al.* (2002). *Glencoe Earth Science.* The McGraw-Hill Companies, Inc.

Maton, Anthea *et al*. (1999). *Exploring Earth Science.* Prentice Hall.

Tarbuck, E.J. *et al*. (2009). *Earth Science 12th ed*. Pearson Education South Asia Pte Ltd.

Electronic Sources:

http://www.geomag.bgs.ac.uk/education/reversals.html accessed March 1, 2014

https://www.princeton.edu/~achaney/tmve/wiki100k/docs/Asthenosphere.html accessed March 1, 2014

http://www.learner.org/courses/essential/earthspace/session3/closer2.htm accessed March 3, 2014

http://loki.stockton.edu/~hozikm/geol/Courses/The%20Earth/Content%20Web%20Pages/Bugielski/webpage.htm accessed February 28, 2014

http://www.cyberphysics.co.uk/topics/earth/geophysics/Seismic%20Waves%20Reading.htm accessed March 1, 2014

http://rieson.blogspot.com/2013/02/birth-of-earth.html accessed March 1, 2014

http://www.yourdictionary.com/magnetic-reversal accessed March 31, 2014

http://www.learner.org/courses/essential/earthspace/session3/closer2.htm accessed March 3, 2014

http://www.enchantedlearning.com/subjects/dinosaurs/glossary/Contdrift.html accessed March 7, 2014

http://www.physicalgeography.net/fundamentals/10h.html

https://www.studyblue.com/notes/note/n/geography-terms/deck/4616076

www.furuno.com

https://mrb-science.wikispaces.com/Plate+Tectonics pubs.usgs.gov

fossilmall.com

www.busacagallery.com

huttoncommentaries.com

http://www.yourdictionary.com/magnetic-reversal

www2.chilton.k12.wi.us

http://pubs.usgs.gov/gip/dynamic/continents.html

http://wowlegazpi.com/mayon-volcano-interesting-facts/#stash.Q3mSKqYG.dpbs

Photo credit: Yves Eli Yu

10

Science

Learner's Material
Unit 2

This book was collaboratively developed and reviewed by educators from public and private schools, colleges, and/or universities. We encourage teachers and other education stakeholders to email their feedback, comments, and recommendations to the Department of Education at action@deped.gov.ph.

We value your feedback and recommendations.

Department of Education
Republic of the Philippines

Science – Grade 10
Learner's Material
First Edition 2015

Published by the Department of Education
Secretary: Br. Armin A. Luistro FSC
Undersecretary: Dina S. Ocampo, PhD

Development Team of the Learner's Material

Authors: Herma D. Acosta, Liza A. Alvarez, Dave G. Angeles, Ruby D. Arre, Ma. Pilar P. Carmona, Aurelia S. Garcia, Arlen Gatpo, Judith F. Marcaida, Ma. Regaele A. Olarte, Marivic S. Rosales, Nilo G. Salazar
Reviewers: Eligio C. Obille Jr., Marlene B. Ferido, Ma. Helen DH Catalan, Vic Marie Camacho, Lilia M. Rabago, Cerilina M. Maramag
Illustrators: Joseph V. Bales, Ramon C. Gatpo, Regaele A. Olarte, Marivic S. Rosales, Ruel C. Quindoy, Antonio I. Basilla, Jose Leo Vic O. Albaño
DepEd Specialists: Joseph R. Jacob, Maria Amparo R. Ventura
Photo Credits: Herma D. Acosta, Dave G. Angeles, Liza A. Alvarez, Ruby D. Arre, Aurelia S. Garcia, Judith F. Marcaida, Regaele A. Olarte, Jane Chavarria, Nilo G. Salazar
Layout Artists: Matthew Daniel V. Leysa and Mary Grace Ann G. Cadisal

Printed in the Philippines by REX Book Store, Inc.
Department of Education-Instructional Materials Council Secretariat (DepEd-IMCS)

Office Address:	5th Floor Mabini Building, DepEd Complex Meralco Avenue, Pasig City Philippines 1600
Telefax:	(02) 634-1054, 634-1072
E-mail Address:	imcsetd@yahoo.com

TABLE OF CONTENTS

Unit 2: Force, Motion, and Energy

Overview

Module 1: Electricity and Magnetism

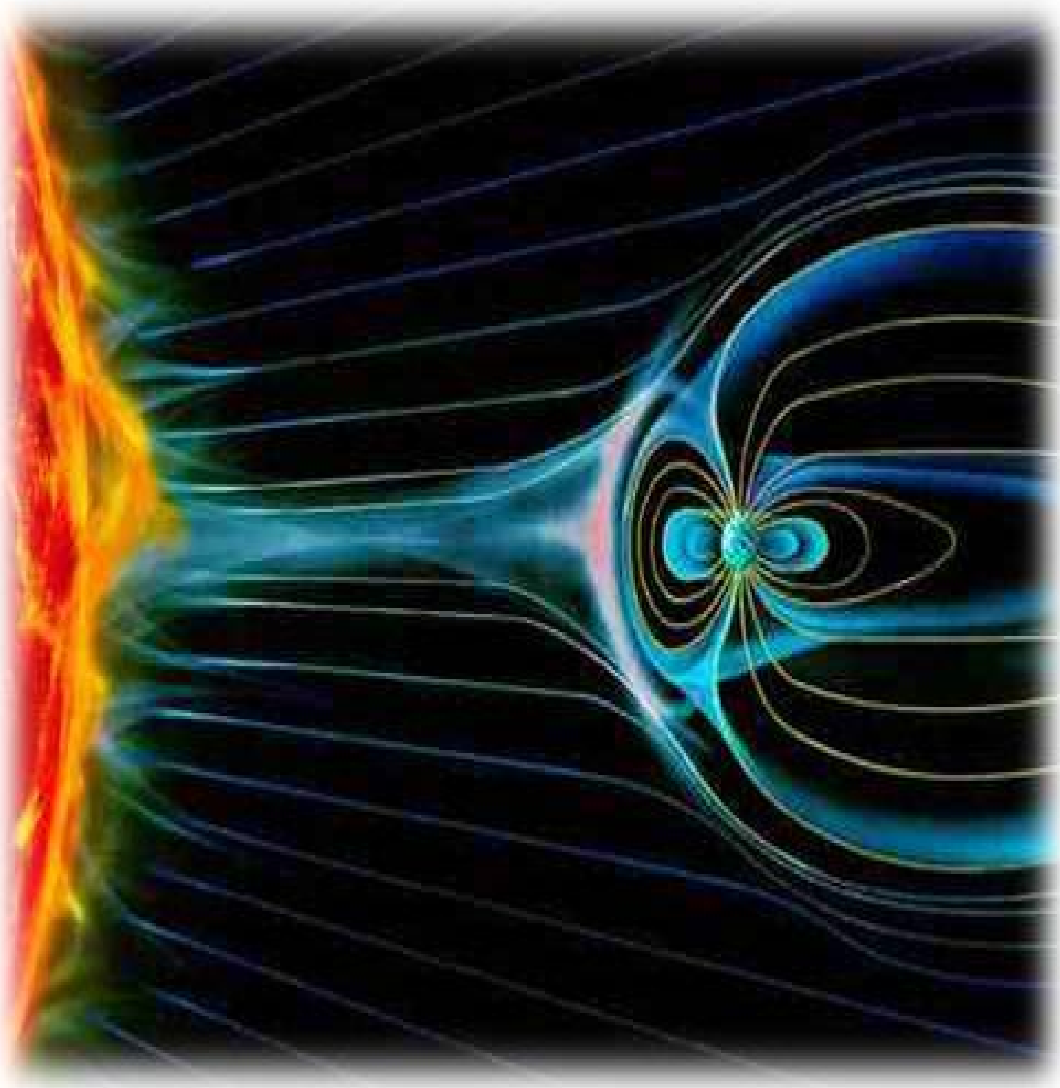
Module 2: Electro Magnetic Spectrum

Module 3: Light: Mirrors and Lenses

UNIT 2

Force, Motion, and Energy

(The electric and magnetic phenomena around us)



UNIT 2: FORCE, MOTION, AND ENERGY

(The electric and magnetic phenomena around us)

Overview

The moving iron core within the Earth acts like a giant bar magnet. It produces a weak geomagnetic field that surrounds and partially protects us from solar radiations. In like manner, the moving charges within the Sun generate an eruption of radiations. This produces a solar magnetic field that spreads throughout the solar system and beyond. Moreover, a solar wind of charged particles constantly interacts with the Earth's changing geomagnetic field.

In Grade 8 Science, you learned some characteristics of heat, visible light, and electricity whereas in Grade 9 Science, you were introduced to the forms and sources of energy. You also learned how electrical energy is generated, transmitted, and distributed. Using the principles of forces, motion and energy, Unit 2 of Grade 10 Science which is intended for the second quarter, supports investigations on the electric, magnetic and electromagnetic phenomena all around us. Eventually, this unit will help you to understand the different electromagnetic waves commonly known as the EM spectrum with a final emphasis on the visible light.

In Module 1, you will be reacquainted with basic magnetism and its relationship with electricity by exploring electric and magnetic fields surrounding devices made up of magnets and current-carrying conductors.

Moreover, a detailed study of the characteristics of the EM spectrum in Module 2 will help you appreciate the relevant applications and effects of some of the EM waves to us and our environment.

Lastly in Module 3, you will study the nature of light as it interacts with matter through reflection and refraction. There will be interesting activities on image formations using different mirrors and lenses.

The chief goal of the activities in these modules is to acquaint you with the particular phenomenon in study, enable you to observe relationships between variables, help you to develop and communicate your tentative explanations of the phenomena or models, and lead you to further inquiry and deeper understanding.

Unit 2
MODULE

1

ELECTRICITY AND MAGNETISM

I. Introduction

In this module, you will map two invisible force fields - the electric and the magnetic fields. Within each field, forces may be exerted on matter causing it to interact with another matter because of electricity and magnetism working as two aspects of a single electromagnetic force.

You will further explore, demonstrate and explain the idea that a changing electric field produces magnetism, and a changing magnetic field produces electric current in the light of technological applications that are helpful to man.

At the end of this module, you are expected to answer the following key questions below and use the learning competencies as study guide:

How is electricity related to magnetism?
How does electricity produce magnetism? How does magnetism produce electricity?
How does an electric motor work? How does an electric generator work?
What is electromagnetic induction?

II. Learning Competencies/Objectives

1. Make a simple device that shows how a magnetic field exerts a force on a wire.

2. Demonstrate the generation of electricity by movement of a magnet through a coil.

3. Explain the operation of a simple electric motor and generator.

III. Pre-Assessment

Direction: Choose the letter of the correct answer.

1. In which case or cases is electric field present?
   I. A spark jumping between two nearby rods.
   II. A charge that is momentarily at rest.
   III. A rotating bar magnet.

   a. I only
   b. I and II only
   c. II and III only
   d. I, II and III

2. In which case can a magnetic field be produced?
   a. A charged comb.
   b. A falling glass rod.
   c. A welder's arc flash.
   d. A rolling plastic cylinder.

3. Which device can be used to determine the polarity of an unmarked magnet?
   a. a charged glass stirring rod
   b. a gold-leaf electroscope
   c. a sprinkle of iron filings
   d. an improvised compass

4. How will you describe the magnetic field around a straight current-carrying wire?
   a. The magnetic field is strongest near and around the wire.
   b. The magnetic field consists of straight lines parallel to the wire.
   c. The magnetic field does not vary with the distance from the wire.
   d. The magnetic field gets stronger with increasing distance from the wire.

5. Which statement about an electromagnet is TRUE?
   a. The electric field surrounding a battery-powered electromagnet alternates constantly.
   b. The current in the electromagnet coil temporarily magnetizes the iron core.
   c. The electric field strength is inversely proportional to the current.
   d. The magnetic field lines produced are all straight.

6. What can be inferred from the alignment of compass needles in the set-up below?

   a. A permanent magnet is nearby.
   b. The power switch was turned off for long.
   c. The current-carrying coil becomes magnetic.
   d. There is a constant and uniform magnetic field around the coil.

7. As part of a traffic light system, large loops of wire are buried beneath road intersections. Which of the statements is NOT TRUE about the operation of this traffic light system?
   a. Vehicles driven over the buried coils activate a traffic light sensor.
   b. The conducting loops activate a color–dependent field.
   c. The alternating current sent through the buried coils produce an electromagnetic field in each coil.
   d. A minimum number of vehicles over the coils can trigger the traffic light to change green.

8. Complete the following statement: Moving a metallic detector past a 5 peso coin creates a secondary magnetic field that is most similar to that of __.
   a. a horse shoe magnet
   b. a flat refrigerator magnet
   c. a current-carrying, circular loop
   d. a V-shaped straight wire that carries a current

9. During the Student Technologists and Entrepreneurs of the Philippines (STEP) Competition in Landscaping, a water pond transformer changes 216 V across the primary to 12 V across the secondary. If the secondary coil has 10 turns, how many turns does the primary coil have?
   a. 10 turns
   b. 18 turns
   c. 180 turns
   d. 228 turns

10. What basic principle enables ALL electric motors to operate?
    a. Iron is the only element that is magnetic.
    b. Opposite electric charges attract and like charges repel.
    c. A moving conductor within a magnetic field will experience an electromotive force.
    d. A current-carrying conductor placed within a magnetic field will experience a magnetic force.

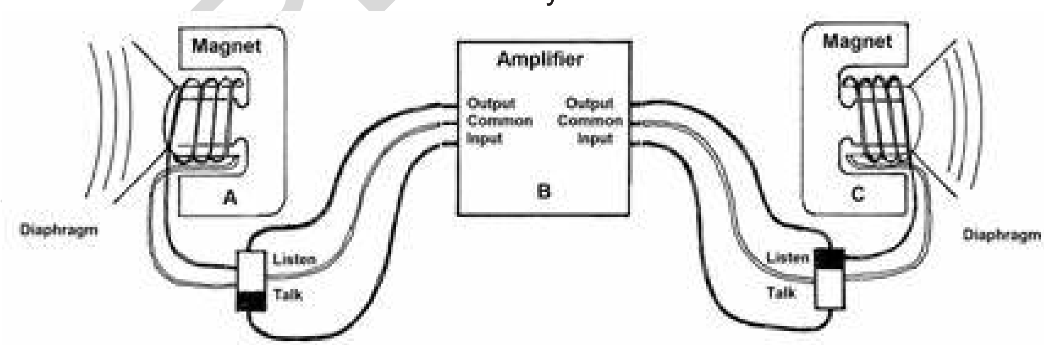
11. A magnet moves inside a coil. Consider the following factors:

    I. strength of the magnet
    II. number of turns in the coil
    III. speed at which the magnet moves

    Which can affect the electromotive force (*emf*) induced in the coil?
    a. I only
    b. II only
    c. III only
    d. All three factors

12. Which statement about transformers is FALSE?
    a. A step-down voltage transformer steps up the current.
    b. Transformers use mutual induction.
    c. Transformers are an application of Faraday's and Lenz's Laws.
    d. A transformer can function with either an alternating current (AC) or a steady direct current (DC).

13. What is TRUE about the intercom system that is shown below?



    a. The part A of the intercom system serves as a microphone only, while part C serves as a loudspeaker only.
    b. Either parts A and C of the intercom when switched as such can be used as a microphone or as a loudspeaker.
    c. The microphone part only basically consists of wires, a cone diaphragm, a magnet, and a coil.
    d. The loudspeaker part only basically consists of wires, a cone diaphragm, a magnet, and a coil.

14. What transformation can take place in an improvised generator?
    a. mechanical energy into electrical energy
    b. electrical energy into mechanical energy
    c. alternating current into direct current
    d. direct current into alternating current

15. A loop of conductor lies flat on a horizontal table. A toy magnet is hanging still over it with the magnet's north-seeking pole pointing down. What happens next?
    a. The magnet produces a clockwise current in the coil.
    b. The magnet does not produce any current in the coil.
    c. The magnet produces an upward electromagnetic current.
    d. The magnet produces a counterclockwise current in the coil.

IV. Reading Resources and Instructional Activities

GETTING HOOKED ON ELECTRICITY AND MAGNETISM APPLICATIONS

AVPs: *Veni, vidi, vici.*
(Audio-Visual Productions*: I came, I saw, I conquered.)*

People readily adopt emerging technologies. The use of audiovisual (AV) works be it in film productions, in business displays, or perhaps in education innovations became a trend and it is here to stay. Examples abound like our growing love for the high quality audiovisual components we listen to and watch or the endeavor of school stakeholders to provide projection technology in every classroom.

The rise of it all AV production, recording, and storing technology and industries were made possible because of the discovery of the link between electricity and magnetism. How does one begin to understand this partnership? For a start, consider doing the activity regarding audio recording devices.

Activity 1

For the Record…

(Adapted from the EMI Teaching Sequence by Jenaro Guisasola and Kristina Zuza)

Objectives:

- Identify the basic recording equipment of a digital radio studio.
- Classify whether devices use electricity and/or magnetism when used in recording audio.
- Start a literature search on electromagnetic induction's role in recording technology.

Materials:

- pictures of the radio studio control and audio room *OR*
- video clip on a radio station tour, video player, screen, and accessories
- pen and activity sheet/science notebook

Procedure:

PART A. Virtual Tour of a Radio Broadcasting Studio

1. Read the scenario and study the video clip or pictures selected by your teacher, similar to what is shown in Figures 1 to 3.

> **Activity Scenario:** During non-class hours, you frequently meet your friends playing and making music together. One afternoon you decided to go to your local radio station to ask what equipment and software is needed to start recording at home.
>
> At the broadcast studio, with the radio technician out, the staff allowed you to take pictures inside the control room and live audio room, similar to what is shown in Figures 1 to 3.

Figure 1. A control room of a local radio broadcast studio commonly known as the announcer's booth. (Used with permission from the RPN-DXKO Radio and Television Broadcast Station in Cagayan de Oro City.)

2. On your science activity notebook, make a table, similar to Table 1. List all the equipment that you can identify in the photo shown in Figure 1. Indicate with a check mark whether the equipment/device needs electricity and/or magnetism to operate.

Table 1. Radio Broadcast Studio Equipment (Control Room/Announcer's Booth)

Equipment/Device	Needs Electricity	Needs Magnetism

Guide Questions:

Q1. How many of the devices you identified inside the control room need electricity to operate?

Q2. How many of the devices you identified inside the control room need magnetism to operate?

3. On your science activity notebook, make another table similar to Table 2. List also all the equipment that you can identify in the pictures shown in Figures 2 and 3. Indicate with a check mark whether the equipment/device needs electricity and/or magnetism to operate.

Figure 2. A live audio room, commonly known as the newsroom, which is usually separated from the control room via glass partitions.

Figure 3. Back portion of a local newsroom

Table 2. Radio Broadcast Studio Equipment (Live Audio Room/Newsroom)

Equipment/Device	Needs Electricity	Needs Magnetism

Guide Questions:

Q3. How many of the devices you identified inside the live audio room need electricity to operate?

Q4. How many of the devices you identified inside the live audio room need magnetism to operate?

Q5. What other devices not shown in the photo may be used inside the live audio room?

KEY CONCEPTS

- A typical broadcast studio consists of an audio console, microphones, computers, studio monitors, and disc players.
- The audio console converts analog audio (voice via microphone) and phone calls to a digital output. It also allows for the mixing of all sound sources from CDs, computers, and other digital sources before being sent to the transmitter. A slider controls the volume of each sound source.
- The live audio and control rooms are connected by cables for the exchange of audio and digital data signal during recording, mixing, and even editing of all audio-video elements digitally stored on hard drives.

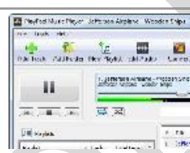
More Reading Support on Recording Technology:

What devices did recording technicians use in the past to record sound?

PART B. My Own Home Recording Studio! For Life…

1. You could be an aspiring singer, a music artist, a student who needs to record audio presentations or simply one planning to have a start-up home recording studio. Use Table 3 and extend your understanding of the recording industry by matching the devices in Column B and their respective functions in Column C with the items in Column A. Write the letter and number for coding your answer.

Table 3. A Home Recording Studio Start-Up Equipment

A	**Coded Answer**	B	C
Picture		Device Name	Function
1. 	**1** ___ ___	A.headphone	I. Used for playing some digital instruments, recording, adding effects, and mixing different sources of sound signals
2. 	**2** ___ ___	B. studio monitor	II. Microphones and musical instruments are plugged into this, which in turn is connected to the computer
3. 	**3** ___ ___	C. audio interface	III. Processor should be reasonably fast enough to record, edit, mix, store, and master a copy of the record.
4. 	**4** ___ ___	D. digital audio software (DAW)	IV. Converts sound into electrical signal
5. 	**5** ___ ___	E. computer unit	V. Used for “referencing” or for checking what the mix would sound like on the equipment
6. 	**6** ___ ___	F. condenser or dynamic microphone	VI. Used for connecting audio interface, microphones, studio monitors, and different instruments
7. 	**7** ___ ___	G. cables	VII. Commonly known as speakers but these give a sound close enough to the real sound input

Extension Activity: Learn more about the basic audio-video recording devices and make a graphic organizer on your science notebook. What parts inside these devices use electricity and magnetism to function as such?

Guide Question:

Q6. Which devices on Table 3 are powered, entirely or partially, by electromagnetic induction (the phenomenon of a changing magnetic or electric field's effect on electricity or magnetism)?

More Reading Support on Recording Technology:

In the development of the recording and data storage technology, what questions might engineers ask?

Think of some questions by now about recording technology. Can handy mobile phones or digital cameras serve as audio-visual recorder and producer? How do these devices apply electromagnetic induction?

KEY CONCEPTS

- Many of the recording technology are founded entirely or partially on the relationship between electricity and magnetism known as electromagnetic induction.
- Devices that detect and convert audio inputs to electric outputs or vice versa are called transducers. Most transducers like microphones and speakers use the "generator effect" characterized by the production of forces due to a changing electric signal within a magnetic field or a changing field near a current-carrying conductor.

To understand electromagnetic induction and its applications especially on electric motors and generators, the next set of activities will help you revisit concepts about magnets and forces associated with it, checking polarities, and analyzing magnetic fields.

SOME BASIC PRINCIPLES OF MAGNETISM

Activity 2

Test Mag...1, 2!

Testing for Evidence of Magnetism

Objectives:

- Identify the forces (attraction/repulsion) between:
  - a. two magets, and
  - b. a magnet and magnetic/nonmagnetic materials.
- Distinguish a magnet (permanent or temporary) from a non - magnetic object.

Materials:

- pair of 3”- 6” bar magnets
- 6-10 objects made of different materials from inside the room
- science notebook and pen

Safety Precautions:

- Handle magnets with care so as not to drop those. These might break, chip off, and weaken upon impact.
- Keep magnets away from computer units/screens, memory storage drives and disks, magnetic tapes, mechanical watches, and the like.

Procedure:

1. Use a bar magnet and explore the possible effect/s it can have on the other magnet when made to interact. On your science notebook, make a table similar to Table 4 and record the observed force effect/s. Answer also the guide questions.

Table 4. Interaction between two permanent bar magnets

What I did to the pair of magnets to cause interaction…	Observed effect/s (attracted or repeled)

2. This time, use only one bar magnet and explore its possible effect/s on six to ten different objects found inside the classroom. Record the observed effect/s on a table similar to Table 5. (Exclude record on objects with no observed interaction with the magnet.)

Table 5. Interaction of a bar magnet with other objects

Objects that interacted with the magnet…	Observed effect/s (attracted or repeled)

Guide Questions:

Q7. What conditions with observable effects make magnets interact with another magnet?

Q8. In general, what conditions with observable effects make magnets interact with non-magnet materials?

Q9. What type/s of force can a magnet exert on another magnet?

Q10. What type/s of force can a magnet exert on non-magnet objects?

Q11. How will you distinguish magnets from non-magnetized magnetic materials?

KEY CONCEPTS

- Magnets exert either a force of repulsion or attraction.
- If a force of attraction only is possible between an object and a magnet, then the object interacting with the magnet contains a ferromagnetic substance and is considered naturally magnetic.
- If a force of repulsion is also possible between an object and a magnet, then the object interacting with the magnet may also be a permanent magnet or a temporarily magnetized ferromagnetic material.

Extension Question: What are the magnetic materials found in the audio and video recording tapes?

Activity 3

Induced Magnetism

Objectives:

- Induce magnetism in a magnetic material.
- Infer the polarity of the magnetized object.

Materials:

- bar magnet
- four 1-inch iron nails, screws, or paper clips
- science notebook and pen

Safety Precaution:

- Handle the magnet with care so as not to drop it. It could break, chip off and weaken upon impact.

Procedure:

1. Use the bar magnet and nails to find answers to the questions below. Record your answers on your science notebook. Use diagrams to support your answers.

Guide Questions:

Q12. What happens if you bring two iron nails close to (or touching) each other?

Q13. If you bring a bar magnet close to (or touching) the first iron nail, can the first iron nail attract and lift a second nail? A third one?

Q14. What happens if vary/change the distance between the magnet and the nail/s?

Q15. If the north pole of the bar magnet suspends the first nail by attraction, what is then the nails's polarity of induced magnetism in the indicated regions? Why?

Figure 4. Magnetic Induction on Hanging Screws

2. Choose the correct term from the enclosed choices that should go into the blank spaces on the "Sum it Up Challenge!"

Sum it Up Challenge!

The process by which the screws become magnets is called _____1______ (*electric / magnetic*) induction. This same process is the reason why magnets _____2______ (*attract / repel*) non-magnetized magnetic substances such as the screw. The screw becomes _____3______ (a *permanent / an induced*) magnet with the end nearer the magnet having _____4______ (*the same / an opposite*) polarity to that of the permanent magnet. Hence attraction happens ____5____ (*after / before*) magnetic induction occurs.

A quicker way to know the polarity of a permanent or induced magnet is by the use of a magnetic compass which you will be using in the next set of activities.

Activity 4

Detecting and Creating Magnetism

Objectives:

- Identify the polarities and strengths of a bar magnet and magnetized objects using a compass.
- Demonstrate magnetization by stroking.

Materials:

- at least 2 small magnetic compasses
- one 3-inch iron nail
- masking tape or cork stopper
- paper or any small scooping device
- cellular phone/any gadget with camera
- strong bar magnet
- narrow test tube (5/8" wide) or clear straw (5/8" wide)
- science notebook and pen
- iron filings

Figure 5. Materials for Detecting and Creating Magnetism

Safety Precautions:

- Use the magnet, compass, test tube, and the gadget with camera with care so as not to drop any of these.
- Make sure that iron filings remain sealed inside the test tube or the transparent straw (cool pearl taped on both ends). Avoid the iron filings from sticking directly to the magnet.

Procedure:

PART A. North meets south

1. Checking Polarity. Place one magnetic compass on a horizontal surface. Then, move a bar magnet around and above it exploring the strength and polarities of the magnet. If a cellular phone or any gadget with built in camera is available, take pictures of the magnetic compass needle orientations for different locations around the bar magnet. Draw the compass needle directions and write your observations regarding the magnetic field strength on your science notebook and answer the guide questions.

Guide Questions:

Q16. What happens when you randomly move the bar magnet roundabout and above the compass one foot or farther? Nearer than a foot?

Q17. Compass needles are tiny magnets that are free to indicate the north and south poles of a magnet? What do you need to do to know the magnet's polarities?

Q18. What does the compass needles indicate about the iron nail shown below in Figure 6?

Figure 6. Use of Compass Needles for Checking the Magnetism

PART B. By the touch of a magnet

1. Magnetization by stroking. Pour iron filings on a sheet of paper and check whether the filings are still non-magnetized. If magnetized, stir or move the iron filings gently on the paper.

2. Fill carefully the narrow test tube up to a quarter with these iron filings. Cover with masking tape or cork.

3. Hold the closed test tube horizontally. Shake or roll gently with your fingers to level out the iron filings inside.

Figure 7a. Leveling the Iron Filings inside the Test Tube

4. Then when levelled, touch with the north-pole end of the permanent magnet the test tube's curved end. Move the magnet along the test tube from this end to the covered end. Lift the magnet off the test tube and repeat with ten or more strokes. On your science notebook, observe and record what happens inside the tube.

5. Gently lay the test tube on a table and bring compasses near both ends of the test tube as shown in Figure 7.b below. Observe and record what happens.

Figure 7b. Testing Induced Magnetism on the Iron Filings

6. Carefully shake the test tube as shown in Figure 7.c, without moving the compasses. Test for the presence of magnetism again. Record your observations.

Figure 7c. Shaking the Iron Filings inside the Test Tube

Guide Questions:

Q19. In step no. 4 are the iron filings in the test tube magnetized? If yes, which end is the north and which is the south? If no, what else can be done to magnetize it? Try and record your idea.

Q20. What happened to the iron filings magnetism after several shakes?

Extension Activity: Can you magnetize also an iron nail by stroking? Do a quick activity to know the answer for yourself.

KEY CONCEPTS

- Materials which are attracted by a magnet are known as magnetic materials. Iron, cobalt, nickel and many alloys of these metals like steel and alnico are magnetic.
- Magnetic materials can be used to make permanent or temporary magnets unlike the non-magnetic materials which cannot.
- Stroking is one way of magnetization.

Extension Question: What will happen to a magnet if it is dropped too often?

ELECTRIC AND MAGNETIC FIELDS

A Look Back in History:

In 1819, Hans Christian Oersted (ˈƏr-stəd), a professor in the University of Copenhagen, discovered during a class demonstration that a current carrying wire caused a nearby magnetized compass needle to deflect. This observation fired up tremendous research on electromagnetism. As a result, the effect on the motion of conductors placed within a magnetic field (such as in the operation of electric motors) was also experimented much and paved the way for practical electricity.

Twelve years after this discovery, Michael Faraday (ˈFer-ə-dā) conducted his famous induction ring experiment showing that current can be produced by sources of changing magnetic fields. This is the key principle to practical generation of electricity.

The next activities should help you demonstrate and explain the operation of electric motors and electric generators that basically work because of the existing relationship between magnetism and electricity.

Activity 5

Oh Magnets, Electromagnet…

May the forces be in your field!

Objectives:

- Explore the magnetic domains of a latch magnet.
- Observe and draw magnetic field patterns surrounding different magnets and magnet combinations.
- Observe and draw magnetic field patterns surrounding a simple electromagnet and a current carrying coil of wire.

Materials:

- an improvised magnetic board
- a pair of latch/refrigerator magnets
- a pair of bar magnets
- 1 neodymium magnet
- 1 U-shaped magnet
- 1 disk magnet
- 1 knife switch
- white bond paper
- small magnetic compasses
- one 3-inch iron nail
- science notebook and pen
- 2-m copper wire (AWG # 22)
- connectors with alligator clips
- battery holders with 2 AA battery

(Flat plastic bottle, water/Glycerin, iron filings/iron sand or Bargaja)

Figure 8. Commercial latch magnets (commonly known as flexible sheet refrigerator magnets), and an improvised magnetic board which is made by filling completely a leak-free, flat container (preferably plastic) with water/mineral oil, and magnetic sand.

Safety Precautions:

- Use the magnets, compasses, and magnetic boards with care so as not to drop any of these.
- The neodymium magnet is many times stronger than the ordinary disk magnet that can hold papers on refrigerator doors. Be careful not to get your fingers pinched between this kind of magnet and other magnetic material.

- Open after use the switch for the current-carrying conductors, electromagnetic nail and the current-carrying coil.

Procedure:

PART A. Watch their domains!

1. Use an improvised magnetic board and a pair of latch or refrigerator magnets similar to those shown below to observe magnetic field lines.

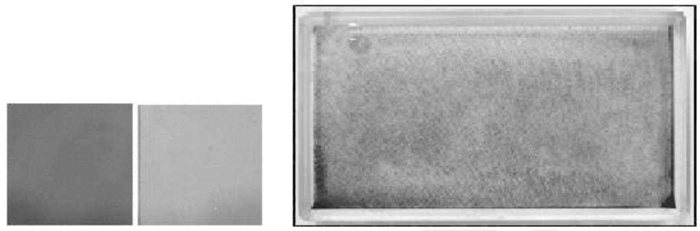


Figure 9. Sample latch magnets, commonly known as refrigerator magnets, and a magnetic board from the public science equipment package. Together, when used, will make the magnetic field surrounding the latch magnets visible. The iron filings suspended in the liquid inside the magnetic board align along the magnetic field lines.

2. Lay each latch magnet under the magnetic board. Tap gently the board until a clear pattern is formed by the iron filings. On your science notebook, draw the pattern made by the iron filings on a table, similar to Table 7. Note the orientations of the magnetic field pattern for each latch magnet. Label if needed.

3. Place one magnet on top of the other. Make sure that they are arranged perpendicularly with each other. Hold the magnet on top as shown in Table 6 below (first row). Slowly and gently pull the magnet (towards you) as shown.

4. Observe what happens. Record your observations on a table similar to Table 6.

Table 6 Interaction of a pair of latch magnets when dragged at different orientations

START OF THE TILTED PULL	END OF THE TILTED PULL	OBSERVATIONS
A. Lightly drag the top latch magnet perpendicularly across the other as shown below. Use the sides with no sticker. 		For perpendicular orientation:
B. Lightly drag the top latch magnet, in parallel, over the other as shown. Use the sides with no sticker. 		For parallel orientation:
C. Lightly drag the top latch magnet obliquely over the other, and at an angle to the horizontal. The 'no sticker' sides should face each other. 		For oblique orientation:

Guide Questions:

Q21. What have you noticed when you pulled the magnet on top perpendicularly across the other? What does this tell you about the magnetic field around the latch magnet?

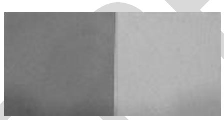
Q22. How do you relate the flapping interactions of the latch magnets, at different orientations, to their magnetic domains?

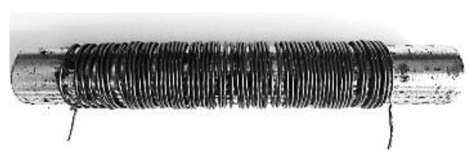
Ideas for Research: The hidden structure of a refrigerator magnet can serve as a model for how a scanning probe microscope (SPM) works. This tool has a super sharp tip that is only one atom thick, allowing nanoscientists to probe across a nanoscale surface. (A nanometer is a billionth of a meter.) What new recording materials did scientists probe, study, manipulate, and control using nanotechnology?

PART B. Within the lines…

1. Place the different magnets and electromagnets under the improvised magnetic board one at a time. Each time, gently tap the magnetic board until a clear pattern is formed. On your science notebook, draw the pattern made by the iron filings on a table similar to Table 7.

Table 7. Magnets and Current-carrying Conductors

Latch Magnets 	U-shaped Magnet 
Between North – North Poles of Two Bar Magnets 	Between South – South Poles of Two Bar Magnets 

Between North – South Poles of Two Bar Magnets 	Single Bar Magnet 
Disk Magnet and a Neodymium Magnet 	Iron nail wrapped with current-carrying wire  - +
Straight Current-carrying Wire  - +	Current-carrying Coil  - +

Guide Questions:

Q23. Compare the magnetic field patterns drawn in Table 7. What similarities differences have you seen among them?

Q24. What do the magnetic field patterns, shown on the magnetic board indicate about the strength of the magnets?

Q25. What do the magnetic field patterns indicate about the forces of interaction between magnets?

Q26. How will you use the button compasses to describe/determine the forces of interaction between magnetic poles?

In the previous activities, you have detected and describe the invisible magnetic field line patterns around different sources of magnetism using the magnetic board.

Activity 6

Electric Field Simulation

Electric Fields, Forces, and Forms (E-3Fs)

Objectives:

- Predict the electric field directions and patterns in different locations surrounding charges and combinations of it.
- Relate electric field strength *E* to distance quantitatively and qualitatively

Materials:

- Table 8 Electric Fields, Forces, and Forms (E-3Fs)
- Science notebook and pen
- PC unit and accessories installed with PhET Interactive Simulation (for an actual offline or online activity)

Procedure:

1. Study the letter-coded images of charges and electric fields in Table 8. Each image will help you explore the PhET-generated electric field patterns, electric field directions, and electric field strengths.

2. Match these images to the numbered descriptions shown on the upper left of Table 8. Using the number and letter codes, write your answers on your science notebook.

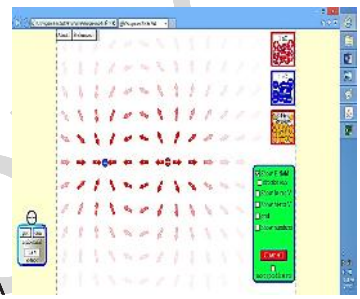
Table 8. Electric Fields, Forces, and Forms (E-3Fs)

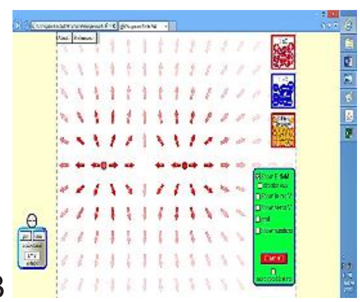
Match the electric charges and field descriptions with the images shown below from the PhET simulations on Electric Charges and Fields. Write your answers using the number and letter codes on your science notebook.

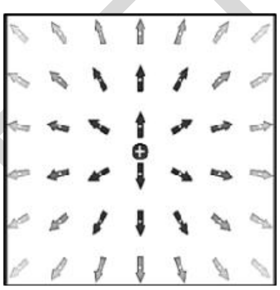
Electric Charges and Field Descriptions

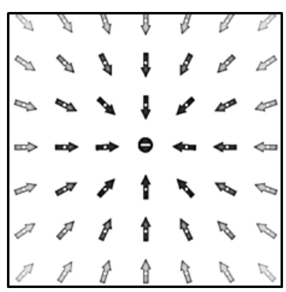
E

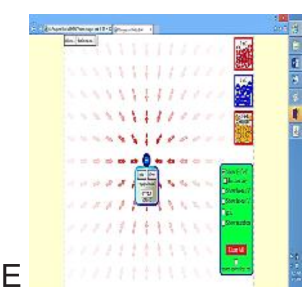
1. Electric field pattern for two negative charges near each other
2. Direction of electric field lines for a negative charge
3. Direction of electric field lines for a positive charge
4. Electric field pattern for two positive charges near each other
5. Electric field strength near the negative charge
6. Electric force for negative charge
7. Electric field strength far from the negative charge
8. Electric field pattern for two unlike charges near each other

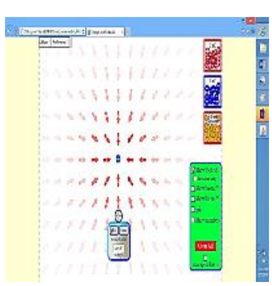

A

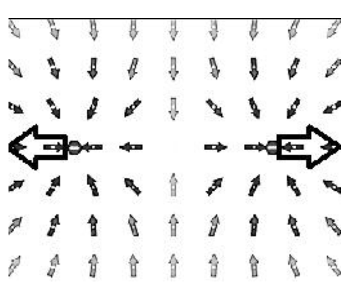

B

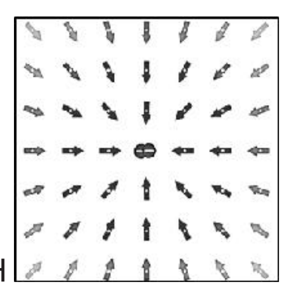

C


D


E


F


G


H

Optional Activity: PhET-based interactive simulation on electric fields

- For online simulation, navigate http://phet.colorado.edu through a web browser. Offline versions can also be downloaded and installed. Once installed, simple click the PhET icon to open the installed program.

- Next click “play with Sims,” then “Physics,” then “Electricity, Magnets and Circuits.” Then choose the “Charges and Fields” simulation. Click “Run now” to start the simulation.

- Once the simulation opens, play with the controls of the simulation to navigate.

The University of Colorado shares for public use an online and offline version of “The PhET Interactive Simulations Project” under the Creative Commons-Attribution 3.0 license and the Creative Commons GNU General Public License at http://phet.colorado.edu.

Activity 7

Magnetic Field Simulation

Magnetic Fields, Forces, and Forms (M-3Fs)

Objectives:

- Predict the magnetic field directions and patterns in different locations around the earth, a bar magnet and combinations of magnets.
- Relate magnetic field strength to distance quantitatively and qualitatively.

Materials:

- Table 9 Magnetic Fields, Forces and Forms (M-3Fs)
- Science notebook and pen
- PC unit and accessories installed with Physlet Physics and PhET Interactive Simulation (for an actual offline or online activity)

Procedure:

1. Study the number-coded images of magnets, compasses and magnetic fields in Table 9. Each image will help you explore the *Physlet Physics and PhET-generated magnetic field patterns, magnetic field lines directions, and magnetic field strengths.

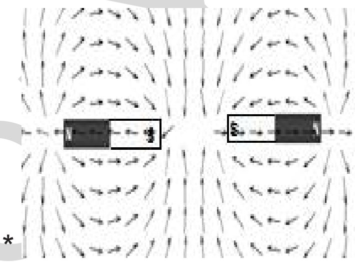
2. Match these images to the letter-coded descriptions shown on the upper left of Table 9. Using the number and letter codes, write your answers on your science notebook.

Table 9. Magnetic Fields, Forces, and Forms

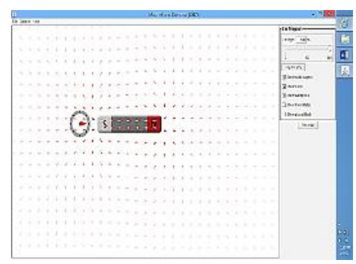
Magnets and Magnetic Field Descriptions

A. Magnetic field pattern for two south poles near each other	B. Magnetic field pattern for two north poles near each other	C. Magnetic field pattern for two unlike poles near each other
D. Direction of magnetic field lines for a south pole		
M	E. Magnetic field strength near the poles	
F. Direction of magnetic field lines for a north pole		
G. Magnetic field strength far from the poles		

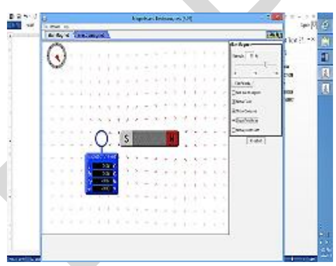
Match the magnets and magnetic field descriptions with the images shown below from the PhET: Magnets and Compass, and the *Physlet Physics simulations. Write your answers using the number and letter codes on your science notebook.



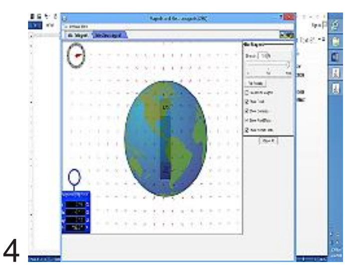
1*



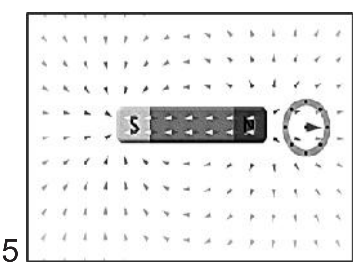
2



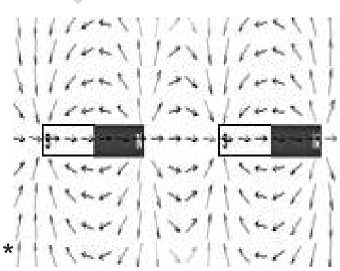
3



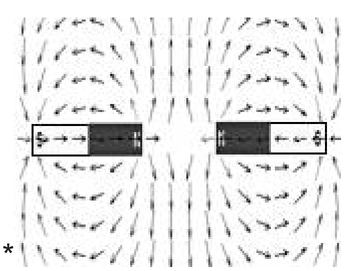
4



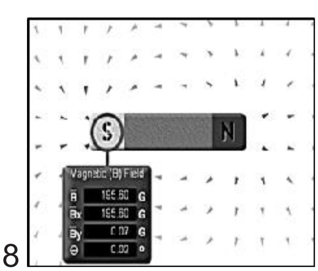
5



6 *



7 *



8

Optional Activity: PhET-based interactive simulation on magnetic fields

- For online simulation, navigate http://phet.colorado.edu through a web browser. For offline version, click the PhET icon to open the installed program.

- Next click “play with Sims,” then “Physics,” then “Electricity, Magnets and Circuits.” Then choose the “Magnets and Compass” simulation. Click “Run now” to start the simulation.

- Once the simulation opens, play with the controls to get used to the simulation. You can move the compass and the bar magnet around on the playing field and then add the earth. How does the magnetic field lines change inside and outside of the magnet as you vary the magnet’s strength? You can also use the field meter to qualitatively and quantitatively compare magnetic field changes.

Sum it Up Challenge!

On your science notebook, make any graphic organizer that will compare and contrast the concepts you learned about:

- The electric field and magnetic field patterns (directions and strengths).
- The electric and magnetic forces acting within the electric and magnetic fields.

The purpose of the next set of activities is to introduce current into a wire conductor and observe the response of the compass needle at some locations around the wire.

Activity 8

Magnetic Field Around Current-carrying Conductors

(Adapted from the DepEd-NSTIC Activity on Magnetic Fields and Electric Currents)

Objectives:

- Using a compass, explore the magnetic field around current-carrying conductors.
- Use the compass to determine the direction of the magnetic field relative to the direction of current through:
  a) a straight current-carrying conductor; and
  b) a current-carrying coil.

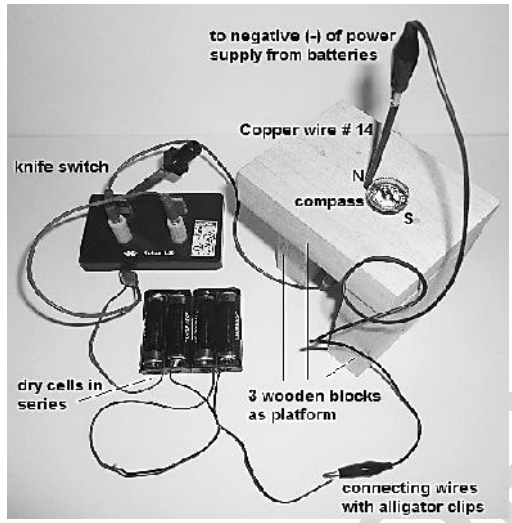
Materials:

- 3 wooden blocks with holes
- 14 gauge insulated copper wire, 20-50 cm
- 4 AA dry cell holders (in series)
- science notebook and pen
- 5 cm^2 used rubber mat
- 1.5 meter hook wire (#22, stranded)
- 3-cm or 4-cm diameter magnetic compass
- 1 button magnetic compass
- 3 or 4 connecting wires
- 1 fuse holder with fuse
- 1 knife switch
- cutter
- tape

Safety Precautions:

- Open the switch after observation to conserve energy. Batteries and wires may become hot if current flows for very long.

Experiment Setup A:



Procedure:

PART A. Magnetic Field around a Straight Conductor

1. Construct the circuit in Setup A as shown above. Make sure the switch is open at the start. The wire should pass vertically at least 10 cm below the wooden block.
2. On the wooden block, position the magnetic compass right next to the vertical wire in four equidistant locations relative to the north-south alignment. For all four locations, rotate the compass until its north axis aligns with the compass needle pointer. The compass shown in the setup is a sample first location.
3. Close the switch long enough for making observations.
4. Observe and draw the deflection (direction and rotation) of the compass needle's north-pole.
5. Open the switch when you are done with your observations.
6. Move the compass to the next locations to map the magnetic field. Do steps 2 to 5 for each of the remaining chosen locations.
7. Draw a short arrow to indicate the compass needle's direction and rotation in each of the four locations.
8. Reverse the polarity of your power supply and do steps 2 to 7.

Guide Questions:

Q27. From a top-view perspective, in what direction does the north pole of the compass needle point to when the compass was positioned around the vertical current-carrying straight conductor?

Q28. From a top-view perspective and with the current's polarity reversed, in what direction does the north pole of the compass needle point to when the compass was positioned around the vertical current carrying straight conductor?

PART B. Magnetic Field around a Coil of Conductor

1. Prepare a compass holder for the larger magnetic compass using a squared rubber mat similar to what is shown in Figure 10. Trace the perimeter of a 3-4 cm wide magnetic compass on a used rubber mat. Safely cut a hole on the mat that is big enough for the compass to fit into. Insert the compass into the hole with the north-south alignment parallel to any side.

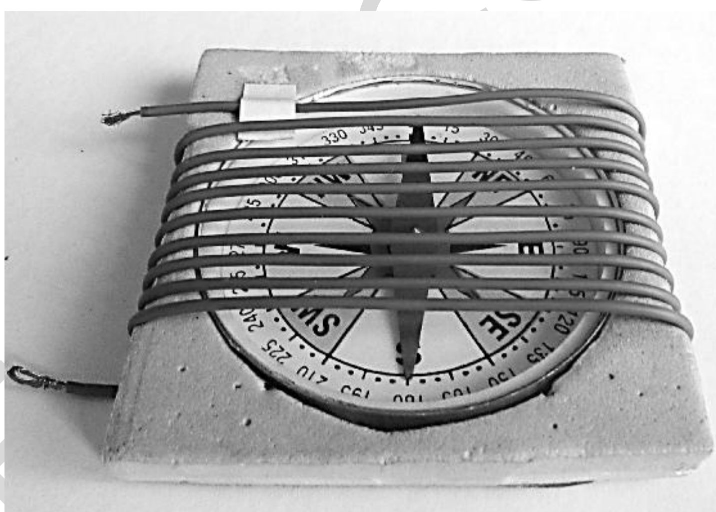
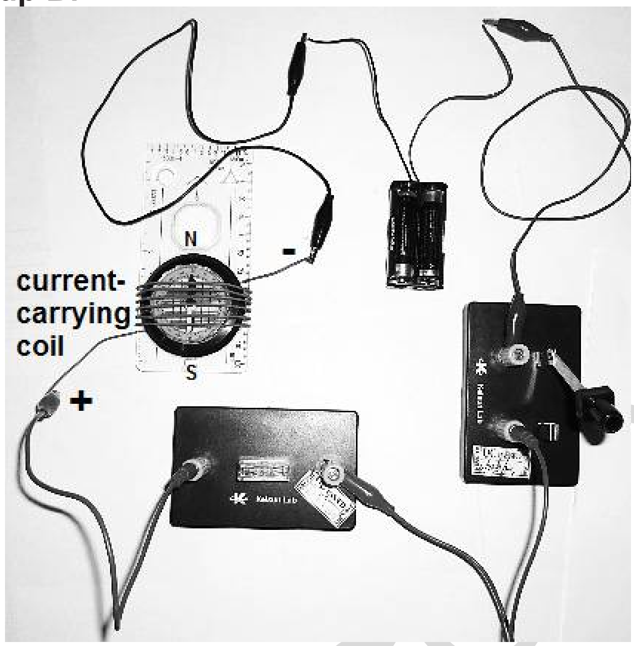


Figure 10. Coil of wire around a compass fitted into a used rubber mat

2. Strip the ends of a 1.5 meter long magnetic hook wire (#22 gauge and stranded) and wind this around the compass on its holder. For easier observations, loop the wire parallel along the north-south axis although the loops can also be oriented perpendicularly. Slowly rotate the rubber mat until the needle points north.

3. Connect the looped wire around the compass to a 3-volt power supply that is in series to the open knife switch and the fuse as shown in Experiment Setup B below.

Experiment Setup B:



4. Close the switch long enough for making observations.

5. Relative to the geographic north-south alignment, observe and draw the deflection (direction and rotation) of the compass needle's north-pole.

6. Open the switch when you are done with your observations.

7. Reverse the polarity of your power supply and do steps 4 to 6.

8. Reduce to half the number of loops around the compass and cut the excess making sure the loops are centered round the compass. Repeat step 3 to 6.

Guide Questions:

Q29. With conventional current flowing counterclockwise, from a top-view perspective, in what direction does the north pole of the compass needle, at the center of the current-carrying coil of wire, point?

Q30. With conventional current flowing clockwise, from a top-view perspective, in what direction does the north pole of the compass needle, at the center of the current-carrying coil of wire, point when the current's polarity was reversed?

Q31. How will you compare the magnitude of the compass needle deflections for the different number of loops in the current-carrying coil?

Q32. If you will straighten the shortened coil of wire, how will you compare the magnitude of the compass needle deflection at the center of the previous current-carrying coil, to the compass needle deflection near the just straightened current-carrying conductor? Why?

9. Extending Inquiry – A solenoid (a coil of wire in which the length is greater than the width) was made using a 3-meter long magnetic wire wound clockwise from left to right around the iron rod. Current was then made to flow through it using a circuit similar to what is shown to Figure 11 a.

Q33. What would be the direction of the magnetic field around the current-carrying solenoid when the switch is closed?

Q34. Using arrows, draw the magnetic compass needle directions at the indicated locations in Figure 11b. Then indicate which ends of the solenoid acts similar to the north and south poles of a bar magnet.

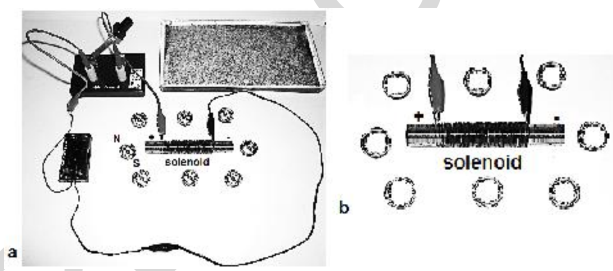


Figure 11. Checking the Magnetic Field around a Current-carrying Solenoid

FORCE ON A CURRENT-CARRYING WIRE IN A MAGNETIC FIELD

A non-magnetic current-carrying wire within a strong magnetic field, like copper for instance, will experience a magnetic force as indicated by the wire's movement relative to the magnetic field. This turning effect on a coil is used in ammeters and motors that use permanent magnets and electromagnets.

Do the next activity and try to understand the interaction between the magnetic field of the permanent magnet and the magnetic field due to the current in the conductor.

Activity 9

Making Your Own Electric Motor

Adapted from http://www.instructables.com/id/How-to-Make-a-Homopolar

Objectives:

- Build a simple electric motor.
- Explain the operation of a simple electric motor.

Materials:

- 1 AA battery
- 3 Neodymium magnets, 1/2" – 3/4"
- pliers or long nose
- AWG #14 – 18 solid and bare copper wire (~30 cm)
- science notebook and pen

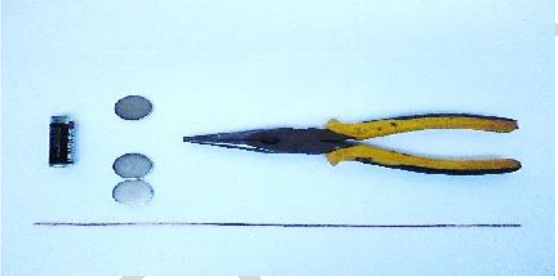


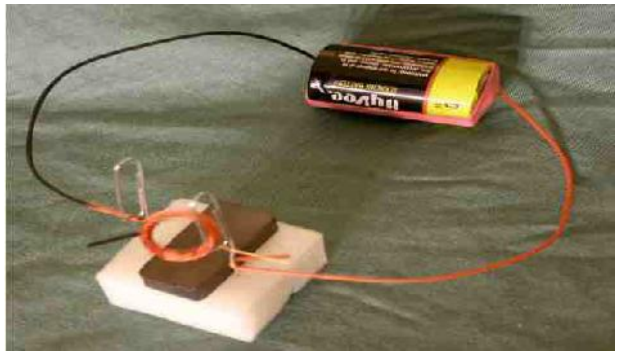
Figure 12. Materials for making an electric motor.

Safety Precautions:

- The neodymium magnet is many times stronger than the ordinary disk magnet that can hold papers on refrigerator doors. Be careful not to get your fingers pinched between these magnets and other magnetic materials.
- Wires can get hot when connected to the battery for a long time. Open the circuit once you are done with your observations.

Procedure:

1. Assembly of the Electric Motor Model – Cut the length of copper wire into three pieces. With the use of the pliers, shape the three wires into a spiral, square, heart or any figure to your liking similar to what is shown in Figure 13.



http://ideas-inspire.com/simple-electric-motor/

Figure 13. A sample electric motor model using neodymium magnets.

2. Make a sample pile of the three neodymium magnets, the battery and the shaped copper wire. Make adjustments to the length and width of the shaped wire. See to it that there is a bare connection between the wire ends and the neodymium magnet and also between the pivot part (balancing point) of the wire and the positive terminal of the battery. Scrape or sand off the material insulating the wire at these indicated points. Disassemble the set up when making the needed shape adjustments and sanding of the copper wire.

3. Testing of Model – Carefully pile with the three neodymium magnets and the battery on a level surface. Mount the shaped wire, with its pivot part as a rotating point, over the positive terminal of the battery. Check that the bottom ends of the wire curl loosely around the magnets forming a closed circuit. You now have a simple DC electric motor model that we will simply call a DC motor model. Give the current-carrying shaped wire a gentle spin.

4. Observe and record what happens to the shaped wire. ***Warning!*** Disconnect the DC motor model immediately after making observations.

5. If your DC motor does not work, stretch your tolerance, abilities, and knowledge. Have fun making your motor model demonstrate the effect of an electromagnetic force on a conductor that is within a magnetic field.

Guide Questions:

Q35. What happens to the shaped wire once positioned over the battery's positive terminal and with both wire ends curled loosely touching the magnets?

6. Extending Inquiry of Model – Tinker with your electric motor model and try to look for other ways to demonstrate the same effect by an electromagnetic force.

Q36. What other observations have you made regarding your electric motor model?

Q37. What will happen if the number of neodymium magnets used in the model is reduced? Increased?

Q38. What are the basic parts/elements of a simple electric motor?

Q39. Based on the activity, how will you explain the operation of a simple electric motor?

ELECTROMAGNETIC INDUCTION

Now the basic parts of a DC motor can also be assembled to operate as a DC generator. What would happen if instead of causing a current-carrying conductor to move within a magnetic field, the closed circuit conductor is mechanically moved within a magnetic field?

The next activity will enable you to explore and appreciate the Earth's magnetic field and its effect on a moving giant coil. Jump in for a simple yet electrifying experience!

Activity 10

LET'S JUMP IN!

(Adapted from cse.ssl.berkeley.edu/.../lessons/...electromagnetism/mag_electromag.pdf)

Objectives:

- Observe the deflection of a galvanometer needle when an electrical cord crosses the Earth's magnetic field.
- Measure and record the magnitude of the deflection of the galvanometer needle when the electrical cord is rotated:
  - a) slowly;
  - b) quickly;
  - c) when aligned east to west; and
  - d) when aligned north to south.
- Explain the operation of a simple electric generator.

Materials:

- 10 to 20 meters flat wire (double wire, stranded) AWG #22
- two lead wires with alligator clip on at least one end
- level field or ground (at least 6 meters x 6 meters)
- micro-ammeter or galvanometer
- pliers or long nose
- one compass
- science notebook and pen

Safety Precautions:

- A galvanometer is a very low resistance instrument used to measure very small currents in microamperes. It must be connected in series in a circuit. Use the galvanometer with care and without dropping it.
- Jump in safely and observe taking turns.

Procedure:

1. Strip off at least 1” insulation on all ends of the 20 meter flat wire. Loop the stranded wires together for each end. Connect the ends of the jump wire to the terminals of the galvanometer using the connecting wires with alligator clips.

Figure 14. Generation and detection of electricity using the Earth’s magnetic field and rotating loop of conductor connected in series to a galvanometer

2. Lay the loop of wire together with the galvanometer on the ground. This long loop of cord-galvanometer arrangement will serve as the closed circuit jump rope electric generator. The galvanometer will serve as detector of the electric current that may be generated due to the Earth’s magnetic field and other essential components for electricity.

3. As shown in Figure 14, have members of your group stand on the jump rope, one at the far end and two near the galvanometer to secure the connections and directional marks for the chosen rotation alignment. If possible secure the connections and alignment another way, so everyone gets to observe the galvanometer freely as the cord is rotated during the jumping activity.

4. Align the jump wire electric generator in any of the geographical directions: (a) east to west, (b) north to south, and (c) northeast-southwest directions using a compass as shown in Figures 15 and 16.

5. With half of the loop on the ground, have two group members on each end pick up the free length of cord and rotate it clockwise or counter clockwise (relative to the galvanometer end) like a jump rope as shown in Figure 14 .Take turns rotating the cord and checking the galvanometer, even jumping in for fun during the activity.

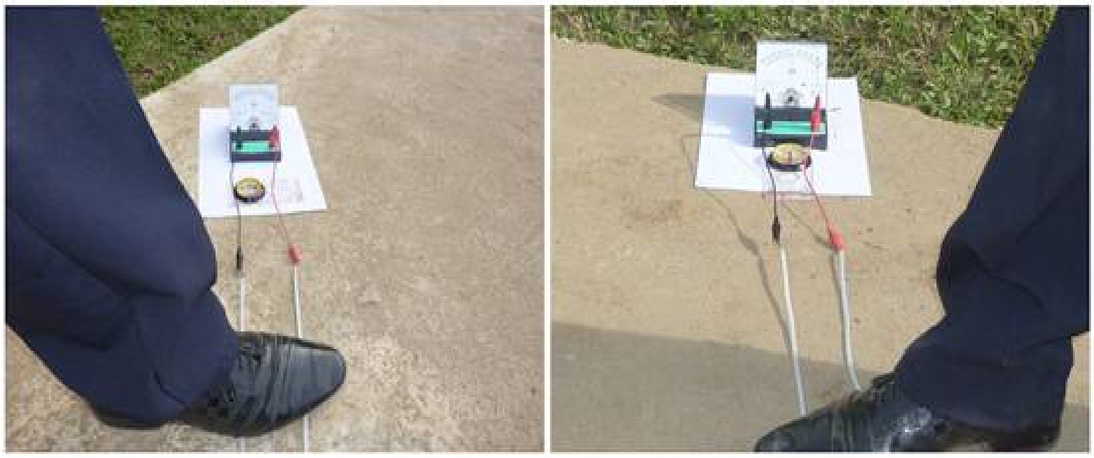


Figure 15. The galvanometer and jump wire electric generator set up along the East-West (left) and along the North-South (right) alignments.

6. Try also rotating both half-lengths of the loop together and observe also the galvanometer reading.

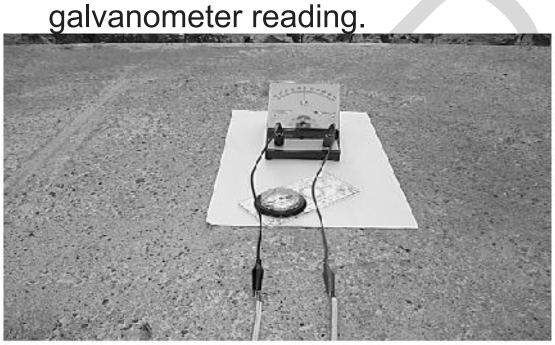


Figure 16. The galvanometer and jump wire electric generator set up along the Northeast-Southwest alignment

Figure 17. when both half-lengths of the loop are rotated together

7. This time try to generate, measure, and record the electric current readings. In doing so try to vary the following:
    A. Speed of rotation.
    B. Geographical alignment of rotation.
    C. Direction of single-length loop rotation.
    D. Length of rotated part.
    E. Single or double half-length rotations.

8. Design and write your own graphic organizer for your observations on your science notebook.

Guide Questions:

Q40. What effect does the rotating part of the loop have on the needle of the galvanometer?

Q41. What effect does the speed of the rotating loop have on the generated electric current?

Q42. Which condition or its combination would result to the greatest generated electric current? Smallest current? No current reading?

Q43. Why does the geographical alignment of the rotating jump wire affect the galvanometer reading?

Q44. What are the basic components of the jump wire electric generator?

Q45. How will you explain the operation of a simple electric generator?

9. Extending Inquiry. Identify and describe the basic parts of the generator model shown in the figure below.

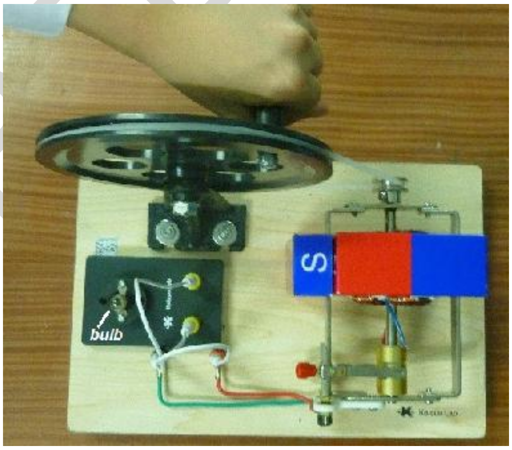


Figure 18. DC Electric Generator

Q46. Which part/device shown in the figure above?

The activity on the jump wire generator operates using the principles of electromagnetic induction. In this activity, it is the conductor that moves within the Earth's magnetic field. Will moving a source of magnetic field instead of the conductor lead to the same findings?

Activity 11

PRINCIPLES OF ELECTROMAGNETIC INDUCTION

(Adapted from the DepEd-NSTIC Activity on Faraday's Induction)

Objectives:

- Observe the deflection of a galvanometer needle when a magnet moves inside a current-carrying coil.
- Identify and explain the factors that affect the induced current through a conductor.

Materials:

- 3.6 meters hook/connecting wires (about 20 fine strands along the length of insulated magnet wire)
- tape measure
- size D dry cell
- sticky tape and pair of scissors
- galvanometer
- two wooden blocks
- two wires with alligator clips
- pair of bar magnets
- science notebook and pen

Safety Precautions:

- A galvanometer is a very low resistance instrument used to measure very small currents in microamperes. It must be connected in series in a circuit with the pointer at the zero point mark. Use the galvanometer with care so as not to drop it.

Procedure:

1. Using a size D dry cell as guide, wind a 5-turn, a 10-turn, and a 15-turn coil out of a 60-cm, 120-cm and a 180-cm connecting wire respectively. Use small pieces of tape to hold the coil together on two or three areas. Remove the insulation from each end of the coil and strand the fine wires together for easy connection.

2. Set up the galvanometer, wooden blocks and bar magnets as shown in Figure 19.

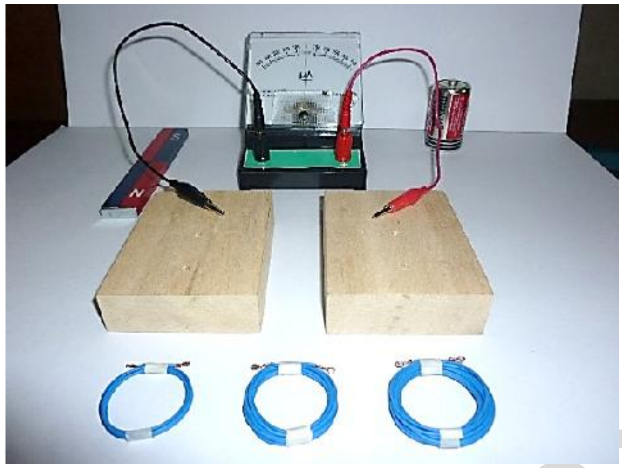


Figure 19. A simple electromagnetic induction activity set up with a galvanometer that has its zero point mark in the center of the scale. This type of galvanometer measures the presence of a very small current, its direction, and its relative magnitude.

Part A. Inducing voltage and current in a coil

3. As shown in Figure 20, lay the 5-turn coil above the two wooden blocks and connect it ends to the galvanometer via wires with alligator clips. At this point, observe what happens to the galvanometer pointer.

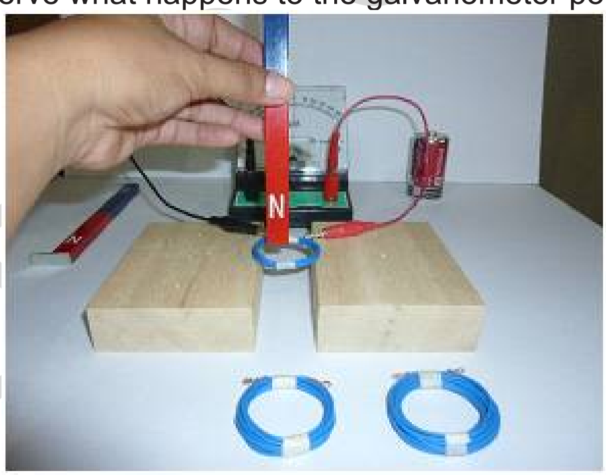


Figure 20. Move the north pole of a bar magnet into a 5-turn coil

4. Hold a bar magnet above the coil as shown in Figure 20. Move the north pole of the magnet into the coil. Observe the galvanometer pointer as you do this. On your science notebook, make a table similar to Table 10 and record your observations.

Table 10. Inducing current in a coil

Condition	Coil Without a Magnet	Magnet is Moving into the Coil	Magnet is at Rest Inside the Coil	Magnet is Moving Out of the Coil
Galvanometer pointer's deflection or non-deflection				
Galvanometer pointer's direction of deflection				

5. Hold the magnet inside the coil without moving it for a few seconds. Observe what happens.

6. Pull the magnet out of the coil. Observe the galvanometer pointer as you do this.

Q47. How will you explain the deflection or non-deflection of the galvanometer pointer as observed in the activity?

Q48. How will you compare the directions of deflection? Why do you think this is so?

Part B. Amount of induced voltage and current vs number of turns

7. Use the set up to explore the relative magnitudes of the galvanometer pointer's deflection for the 5-turn, 10-turn and 15-turn coils. Record your observations on your science notebook.

Q49. For approximately the same speed of moving the magnet into or out of each coil, what happens to the magnitude of the pointer's deflection as the number of turns in the coil increase?

Part C. Amount of induced voltage and current vs strength of magnetic field

8. Use the 15-turn coil and the set up to explore the relationship between the magnitude of the galvanometer pointer's deflection and the magnetic field strength using (a) one bar magnet, and (b) two bar magnets with like poles held together in parallel. Record your observations on your science notebook.

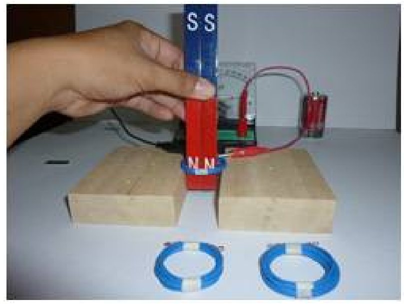


Figure 21. Move the north poles of two parallel bar magnets into a 15-turn coil.

Q50. For approximately the same speed of moving the magnet into or out of the 15-turn coil, what happens to the deflection of the galvanometer pointer as the number of bar magnets (strength of magnetic field) increase?

Part D. Amount of induced current vs rate of magnetic field change

9. Use the 15-turn coil and a bar magnet to explore the relationship between the magnitude of the galvanometer pointer's deflection and the speed of movement of the magnet into or out of the coil. Record your observations on your science notebook.

Q51. What happens to the deflection of the galvanometer pointer as the bar magnet is moved into or out of the 15-turn coil at different speeds (rate of magnetic field change)?

Part E. Coil orientation and direction of magnetic field change

10. As shown in Figure 22, move (a) a bar magnet along one of the coils (preferably the 15-turn) and observe the magnitude of the galvanometer pointer's deflection. Compare this deflection to that when (b) the bar magnet moves across (into or out) the coil at approximately the same speed. Record your observations on your science notebook.

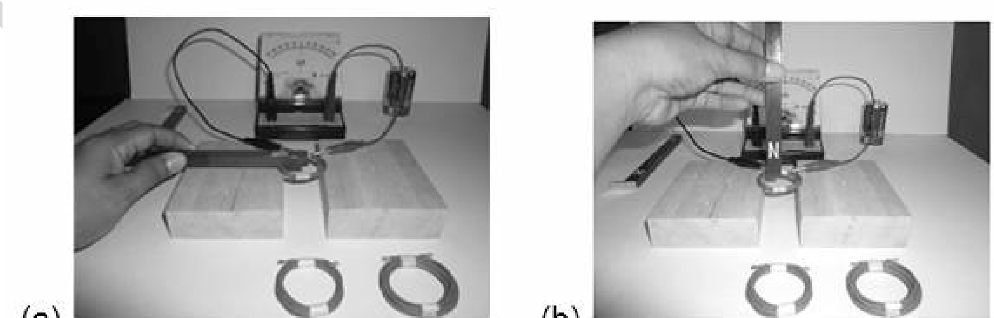


Figure 22. The bar magnet is moved (a) along or parallel to the coil orientation, and (b) across or perpendicular to the coil orientation

Q52. How would you compare behavior of the the galvanometer pointer when the magnet moves along the coil and when the magnet moves across the coil?

Q53. In your own words, what are the factors that affect the amount of current and hence voltage (EMF) induced in a conductor by a changing magnetic field?

Q54. An equation for the electromagnetic force (EMF) induced in a wire by a magnetic field is $EMF = BLv$, where B is magnetic field, L is the length of the wire in the magnetic field, and v is the velocity of the wire with respect to the field. How do the results in this activity support this equation.

11. Extending Inquiry. The principle of electromagnetic induction in two nearby coils can be demonstrated by a transformer. A typical transformer has two coils of insulated wire wound around an iron core. This device changes the AC voltage of the primary coil by inducing an increased or decreased *EMF* in the secondary coil. In practical applications, why does this device operate only on alternating current and not on direct current?

Additional Reading

Speed Control Technology – To ensure road safety and minimize vehicular-related death, buses, and other public utility vehicles can be equipped with a speed control device that limits the maximum speed by using electro-magnetic brakes in combination with a motor once the limit is exceeded.

Speed control motor packages include the motor, the driver (controller), and a potentiometer which allows the driver for easy speed control adjustment. When the speed of this motor is controlled, a tacho-generator connected to the motor detects the speed. It is a magnet connected directly to the motor shaft and stator coil. The stator coil detects the magnetic field and generates an alternating current (AC) voltage.

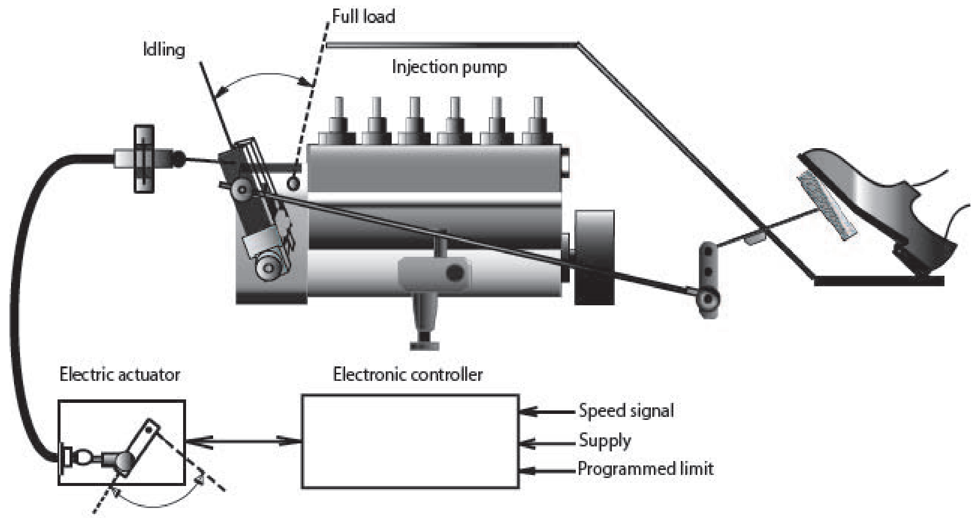


Figure 23. Motor speed control technology diagram

Since this voltage and frequency increase with a rise of the rotational speed, the rotational speed of the motor is controlled based on this signal.

Traffic Light – Vehicles waiting at intersections with coils buried underneath is within an electromagnetic field. Changes in the field activate the traffic light as programmed.

Typical red-light traffic systems have two induction-loop triggers made of rectangular or concentric wire loops buried under the road close to the stop line. This wire is connected to an electrical power source and a meter.

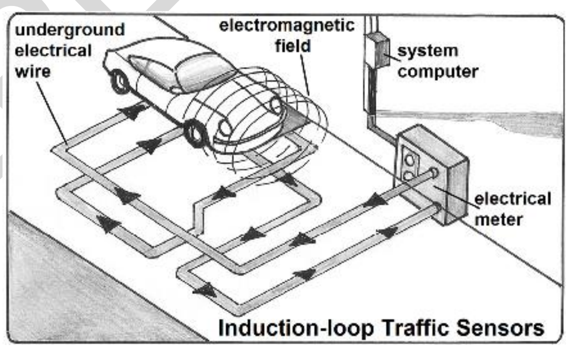


Figure 24. An induction-loop traffic system at a road intersection senses vehicles within its electromagnetic fields

The current through the wire produces a magnetic field affecting objects around the loop and the loop itself. When there is another conductive material within the magnetic field, then a changing induced voltage is detected. This results to changing magnetic flux that triggers the traffic system according to its programmed mechanism.

Metal Detector – Metal detectors trigger the “Bleep! Bleep! Bleep!” sound when objects with parts that are magnetic in nature move past it. This signal a precious find, a hidden unwanted object or a need for further security check.

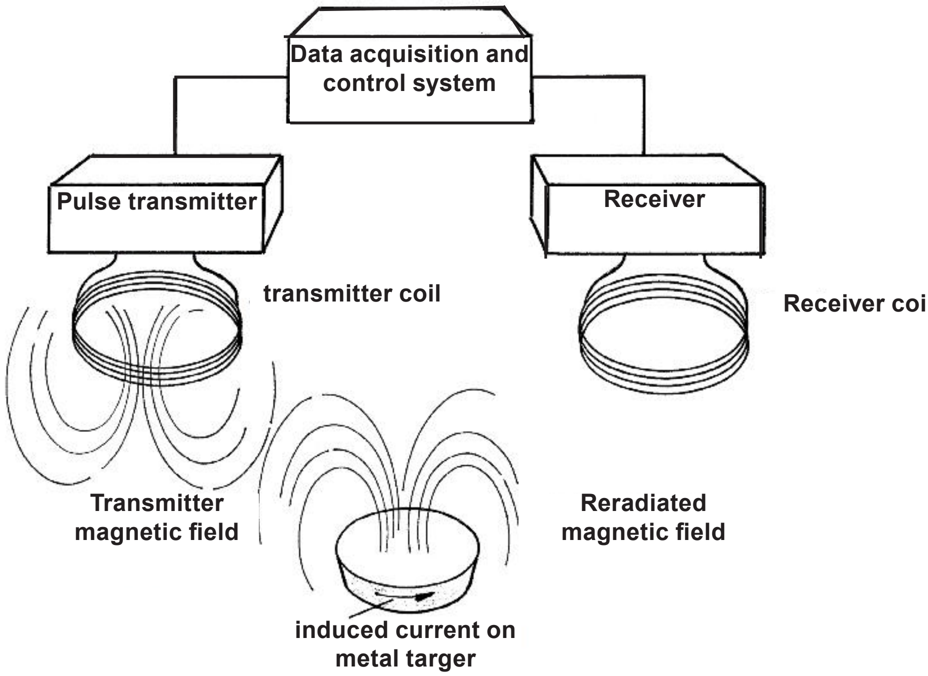


Figure 25. A basic pulse-electromagnetic induction metal detection technique

The transmitter coil is given a pulsed current long enough for the transmitter’s magnetic field to reach the metal target. The transmitter’s loop current is then turned off. The changing or collapsing magnetic field induces an electromotive force that induce charges to flow in the metal target. This induced current creates a reradiated magnetic field that can be detected by a receiver coil located at the sensor.

In some metal detectors, it is the device that is moved over the object. In other detectors, it is the object or the person that moves pass the machine. Whatever is the case, the current-carrying transmitting coil creates a changing magnetic field which in turn creates a changing electric field that creates the secondary magnetic field detected by the receiver coil.

Induction Stove – Food cooks faster when heat is conducted directly and almost entirely at the base of the cooking pot. In induction stoves, current flowing through the copper coil wound underneath the cooking surface produces an electromagnetic field small enough to surround the base of the cooking pot. The magnetic field induces an electric current within the base of the metal pot. The metal in the cookware has electrical resistance that opposes the induced current and causes friction for the pot to heat up.

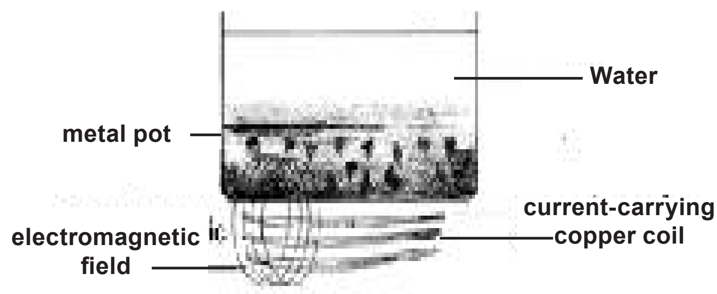


Figure 26. Induction stove working mechanism

Heat transfer in an induction stove is more efficient than that via the gas stove because almost all of its heat is conducted directly to the base of the pot unlike in gas stoves where much heat escapes around the side and heats up the room and the rest of the cooking pot.

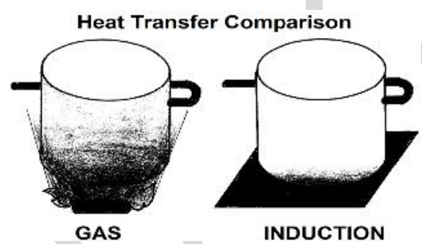


Figure 27. In induction cooking, heat loss is lesser than in gas cooking

Magnetic Recording – Computer working memories (RAM's and ROM's), mass storage memories (magnetic hard disks, floppy disks, magnetic tape drives, and optical disk drives), and practically all write-able card storage devices (magnetic cards, smart cards, and flash memory cards) make use of the magneto-optical characteristic of the recording media to store information.

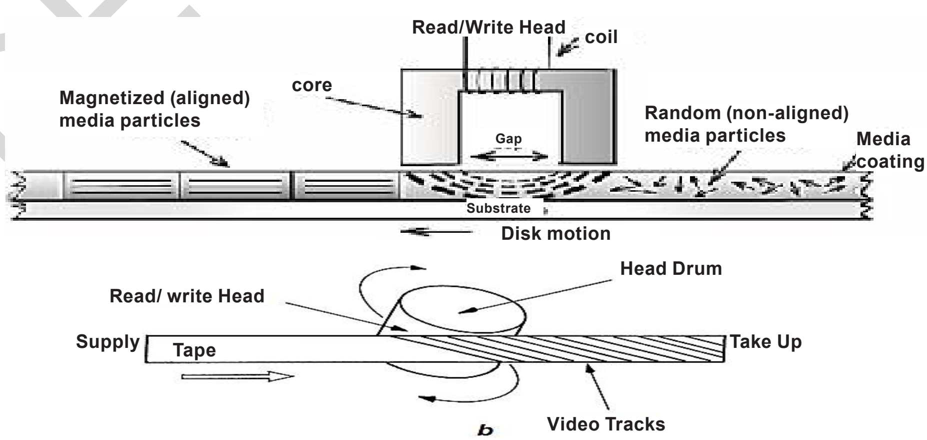


Figure 28. Read/Write Head of a Disk Player

Performance Task

An *Octo* Challenge Audio-Visual Presentation (AVP) Using Electromagnetic Induction (EMI)

An Enrichment Activity

Objective:

Plan, perform, and record a 5-minute audio alone or audio-visual presentation related to any Philippine National Celebration during October using devices that apply both electricity and magnetism.

Materials:

- at least one musical instrument
- audio alone or audio-video recording technology of your choice
- support materials as needed by your team
- printed transcript of spoken parts of AVP

Procedure:

1. Meet as a group and agree on the role of each member according to interests and skills in the making and recording of the AVP presentation.

2. Listed are eight October national celebrations observed by Filipinos:

   - National Children's Month
   - Philippine Consumer Welfare Month
   - Moral Guidance Week for Public Servants
   - Indigenous People's Celebration
   - Elderly Filipino Week
   - Food Safety Awareness Week
   - United Nations Celebratio
   - World Teacher's Day

   Use only one event to highlight in your **AVP tribute** that will introduce briefly the audience to the making and recording of an audio-only or an audio-visual presentation using **electromagnetic induction** partially or entirely.

3. Your group has four weeks to plan, perform and record together the five-minute AVP tribute with the following guidelines:
   a) Gather information about your selected musical instrument and recording device. Learn how these use electricity and magnetism. Give a multimedia introduction on this for a minute or two.

   b) Dedicate the remaining three minutes in highlighting the chosen October event. Decide whether you will record an audio-only or an audio-visual presentation taking into consideration the listening and processing efforts needed to fully appreciate the event or the reason behind it. Plan, perform and record an age-appropriate music-video tribute.

c) Ensure that the AVP is an output of the whole circle of friends. At the end of the AVP include a brief roll of credits.

d) The making and recording of the AVP should be done only during non-class hours inside the school premises only.

e) You are liable for the proper and safe use of all audio-video production and recording devices whether these are personally owned or a school property. Ensure also minimal energy use.

f) Agree on a checklist to help your group monitor your task progress. Prepare also a written transcript of your AVP's recorded audio.

g) Prepare a digital record of your AVP on a compact disc, ready for premiere viewing in the class at the end of this module period.

Criteria for Success - The making and recording of the October-themed AVP will be rated based on the following criteria:

1. Knowledge and understanding of EMI.
2. Thinking and inquiry on the AVP plans and preparations.
3. Communication through language and style.
4. Communication through music and video presentation conventions.
5. Special Criterion on Technical Quality or Original Song Production.

Ask your teacher for this task's **GRASPS** guidelines to help your group in the successful completion of the performance task before the end of Module 1. Refer also to the corresponding performance task rubric for the **Development of an Octo Challenge Audio-Visual Presentation** as you assess your group's progress.

Your teacher will also use the same rubric in assessing your performance, content, and product-wise.

V. Summary/Synthesis/Feedback

- Many of the audio-video recording technology apply the relationship between electricity and magnetism known as electromagnetic induction.

- A typical recording studio consists of an audio-video console, microphones, computers, studio monitors or speakers, disc players and cables used for the exchange of audio and digital data signal during production, recording, mixing, and even editing of all audio-video elements digitally stored on disk drives.

- Devices that detect and convert audio inputs to electric outputs or vice versa are called transducers. Most transducers like microphones and speakers use the "generator effect" characterized by the production of electromotive forces due to either a changing electric signal within a magnetic field or a changing magnetic field near a current-carrying conductor.

- Magnetism is commonly attributed to ferromagnetism and electromagnetism depending on the material and moving charges. Every atom and all moving charges are in constant motion and therefore has a bit of magnetism due to magnetic spins and domains creating a net magnetic field.

- A magnet has two magnetic poles (north and south seeking poles).

- Stroking with a permanent magnet is one of the ways to induce or cause magnetism in an object that can be magnetized. The polarity of the induced magnetism in the object is opposite to the polarity of the nearer end of the permanent magnet. Attraction happens after magnetic induction occurs.

- A magnet attracts, but do not repel, unmagnetized ferromagnetic materials such as iron, nickel, cobalt and some of its alloys like steel and alnico.

- Both forces of attraction and repulsion is possible between magnets and between a magnet and a temporarily magnetized object.

- A magnetic field surrounds a magnet. Within this region, the magnet affects another magnet and other objects that can be magnetized.

- The magnetic field is strongest at the poles where the magnetic lines of induction (flux) are closest. The magnetic field pattern can be shown using iron filings that align along magnetic lines of induction.

- The magnetic lines of induction leave the north-pole and enter the south-pole in close loops and can be indicated by the north pole of a compass.

- The loops of magnetic field lines between like poles bend away from each other showing a force of repulsion. The lines between unlike poles join with each other to form continuous lines showing a force of attraction.

- The earth acts like a giant bar magnet and has a magnetic field similar to it.

- A charge has an electric field around it where other charges will experience an electromagnetic force. Like charges repel while unlike charges attract.

- Moving charges or current in a wire produces a magnetic field.

- An electromagnet is a coil of wire that uses current to produce a strong magnetic field.

- The magnetic field patterns of a disk magnet, an electromagnetic nail, a current carrying straight conductor, and a current carrying coil are similar to that of the single bar magnet.

- The magnetic field pattern between the poles of a U-shaped magnet resembles the field pattern between unlike poles of two bar magnets. Compasses aligned along the magnetic field show that the lines point from the north to the south poles and back forming close loops.

- If the two bar magnets with two unlike poles which are close in between is brought together, the magnetic field pattern will resemble that of the single bar magnet. Lines from one pole enter the other pole.

- Most refrigerator magnets has a pattern of alternating bands of magnetic field.

- If the direction of the current is known, the direction of the magnetic field that is perpendicular to it and the magnetic force that is perpendicular to both current and magnetic field can be determined by applying the hand rules.

- Using the right hand rule, the direction of the magnetic field follows the direction of the right hand fingers when the right thumb points in the direction of the conventional current (from positive to negative).

- Using the left-hand rule, the direction of the magnetic field follows the direction of the left hand fingers when the left thumb points in the direction of the real flow of current (from negative to positive).

- The magnetic field is strongest at the center of a current-carrying coil.

- The magnetic field increases in direct proportion to the number of turns in a coil with the compass needle, at the center of the coil of wire, deflecting about a wider angle than the compass needle along the straightened wire.

- The end of the current-carrying coil where the magnetic lines of induction come out acts as the north pole of the coil.

- A magnetic field exerts a force on a current-carrying conductor. Using the right-hand rule, the direction of this force is in the direction where the palm faces.

- The motor effect is shown when a current-carrying conductor within a magnetic field moves in the direction of the force. The force on a moving current-carrying conductor may be varied by changing the magnetic field.

- An electric motor is a device that converts electrical energy into rotational mechanical energy. A simple DC motor can be assembled using a single coil that rotates in a magnetic field. The direct current in the coil is supplied via two brushes. The forces exerted on the current-carrying wire creates a rotation-causing force on the coil.

- An electric generator is a device that converts mechanical energy into electrical energy. A simple electric generator is made when a coil or any closed loop of conductor moves through or cuts across magnetic field lines. The coil will experience an induced voltage or an electromotive force that will cause a pulsating direct current (DC) to be generated. The pulsating direct current fluctuates in value but does not change direction.

- Electromagnetic induction is a process in which electric current is generated in a conductor by a moving or changing magnetic field.

- A changing magnetic field occurs when there is relative motion between a source of a magnetic field and a conductor; it does not matter which moves.

- A changing magnetic field may also arise from a changing nearby current.

- The amount of voltage (*EMF*) induced when a conductor and a magnetic field are in relative motion depends on (a) the length ***L*** of the conductor or the number of turns in the coil, (b) the strength and orientation of the magnetic field ***B*** relative to the conductor, and (c) The relative velocity ***v*** of the changing magnetic field.

- The equation for the induced voltage or electromagnetic force (EMF) in a wire by a changing magnetic field is ***EMF = BLv***. By Ohm's Law the amount of induced current is directly proportional to the induced voltage.

- A transformer uses electromagnetic induction in two nearby coils (the primary and secondary coils). Typically, the two coils of insulated wire are wound around an iron core. This device changes the AC voltage of the primary coil by inducing an increased or decreased *EMF* in the secondary coil.

VI. Summative Assessment

Directions. Choose the letter of the correct answer.

1. In which case or cases is an electric field present?
   I. A spark jumping between two nearby rods.
   II. A charge that is momentarily at rest.
   III.A dead power line.
   a. I only
   b. I and II only
   c. II and III only
   d. I, II and III

2. Which device can be used to determine the polarity of an unmarked magnet?
   a. a suspended magnetized needle
   b. an improvised magnetic board
   c. a second unmarked magnet
   d. a charged metal rod at rest

3. In which device is magnetic field present?
   a. A charged balloon.
   b. A cooling soldering iron.
   c. A very hot horse-shoe magnet.
   d. A microphone undergoing a sound check.

4. How will you describe the magnetic field around a current-carrying coil?
   a. The magnetic field is weakest near and around the coil.
   b. The magnetic field vary directly with the distance from the coil.
   c. The magnetic field is strongest inside the current-carrying coil.
   d. The magnetic field lines are closed loops along the loops in the coil.

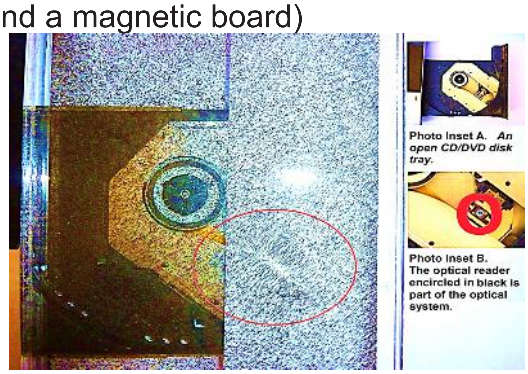
5. Which statement about an electromagnetic nail is NOT TRUE?
   a. Steady magnetic lines of induction surround a battery-powered electromagnetic nail.
   b. The current in the electromagnetic nail demagnetizes the iron nail.
   c. The magnetic field lines produced resemble that of a bar magnet.
   d. The magnetic field strength is proportional to the nail's current.

6. What can be inferred from the alignment of compass needles around the pick-up coil below?

   a. Current is drawn into the coil.
   b. A permanent magnet is nearby.
   c. The DC power switch was turned off for long.
   d. There is a uniform magnetic field around the coil.

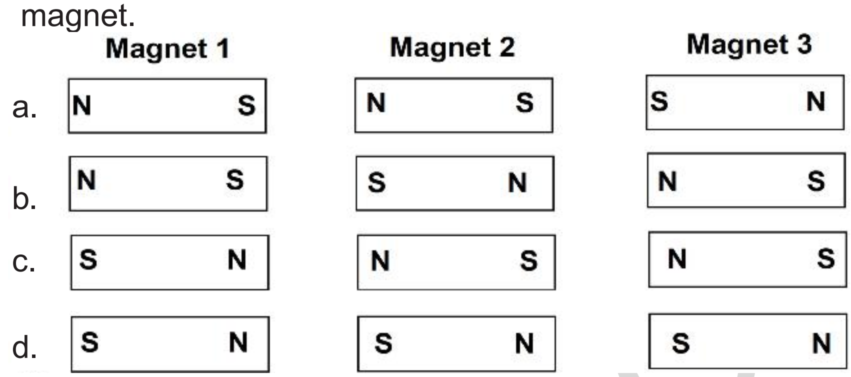
7. What basic principle enables ALL electric generators to operate?
   a. Iron is the only element that is magnetic.
   b. Opposite electric charges attract and like charges repel.
   c. A closed-loop conductor within a changing magnetic field will have an induced electromotive force.
   d. A current-carrying conductor placed within a magnetic field will experience a magnetic force.

8. Which of the following statements can be inferred from the main photo above? (For easier inspection, a paper is inserted halfway between the open disk tray and a magnetic board)



a. The iron filings inside the magnetic board is unaffected.
b. The CD-DVD disk tray uses a small permanent bar magnet.
c. The optical system has an electric motor that drives the reader.
d. The optical reader has a lens system that affected the iron filings.

9. Which arrangement of three bar magnets results to an attraction between the first and the second, and a repulsion between the second and the third magnet.



10. Complete the following statement: A metallic detector was used to check a bag for metallic objects. The transmitter coil
   a. A. draws a steady current to send a steady magnetic field towards the target to induce current in it.
   b. draws a pulsating current to send a steady magnetic field towards the target to induce current in it.
   c. draws a steady current to send a changing magnetic field towards the target to induce current in it.
   d. draws a pulsating current to send a changing magnetic field towards the target to induce current in it.

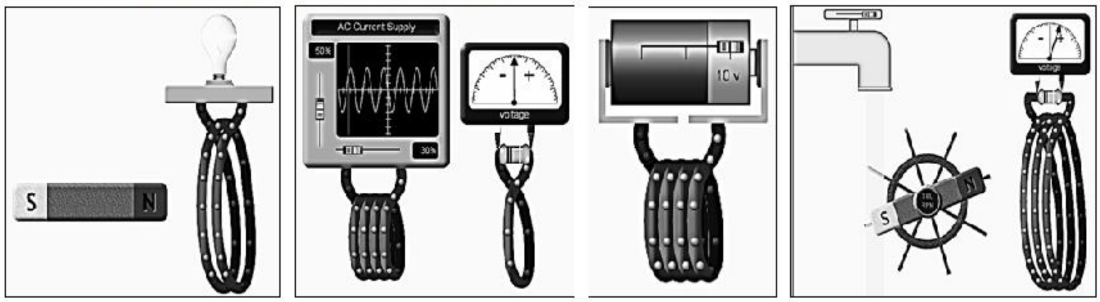
11. A coil moves away from a magnet. Consider the following factors:
   I. strength of the magnet
   II. number of turns in the coil
   III. speed at which the magnet moves

   Which can affect the electromotive force (EMF) induced in the coil?

   a. I only
   b. II only
   c. III only
   d. All three factors

12. Which set ups model the working principle of a transformer and an electric generator respectively?

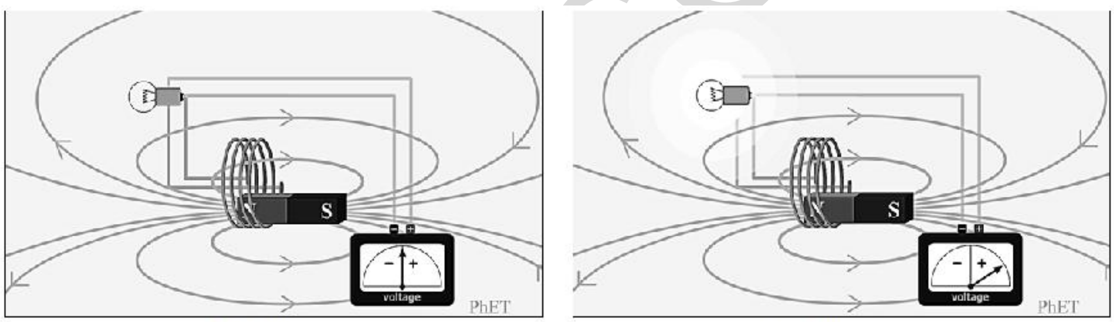
Images from PhET Interactive Simulation



A. B. C. D.

a. A and B b. B and D c. C and D d. D and A

13. Which statement is TRUE about the illustration below?

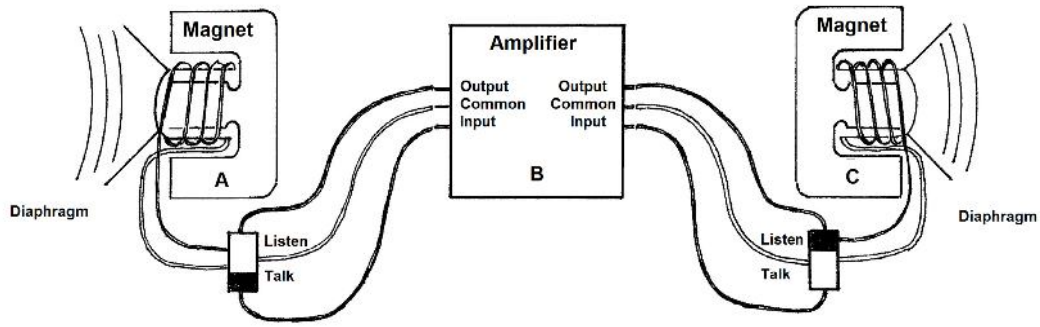


SET UP A. SET UP B.

a. In set up A, the magnet is at rest inside the moving coil.
b. In set up B, the magnet is being pulled out of the moving coil with the same speed.
c. There is relative motion between the magnet and coil in set up A.
d. There is relative motion between the magnet and coil in set up B.

14. What transformation can take place in a ceiling fan's electric motor?
a. electrical energy into mechanical energy
b. mechanical energy into electrical energy
c. alternating current into direct current
d. direct current into alternating current

15. What is TRUE about the intercom system that is shown below?



a. The part A of the intercom system serves as a microphone only, while part C serves as a loudspeaker only.
b. Either parts A and C of the intercom when switched as such can be used as a microphone or as a loudspeaker.
c. The microphone part only basically consists of wires, a cone diaphragm, a magnet, and a coil.
d. The loudspeaker part only basically consists of wires, a cone diaphragm, a magnet, and a coil.

Glossary of Terms

Charged particles — are sources of electric fields which result in an attraction or repulsion of other nearby charges

Electric charge — a fundamental electrical property that is either of positive or negative type to which the mutual attractions or repulsions between protons or electrons is attributed

Electric field — force field surrounding electric charges or group of charges where a force acts on charges within the field

Electric generator — device that converts mechanical energy into electrical energy usually by rotating a coil within a magnetic field

Electric motor — device that converts electrical energy into mechanical energy using the magnetic turning effect on a coil

Electricity — produced by vibrating or flowing charges

Electromagnet	magnet whose magnetic properties are produced by electric current
Electromagnetic induction	phenomenon of inducing a voltage in a conductor by changing the magnetic field near the conductor. If a magnetic field within a closed loop changes in any way, a voltage or electromotive force is induced (produced) in the loop
Electromotive force	voltage that gives rise to an electric current
Galvanometer	low resistance instrument used to measure very small currents, its direction and its relative magnitude
Magnet	object that has the magnetic ability to attract objects made of iron or other magnetic substance
Magnetic Domain	microscopic grouping of atoms with their magnetic field aligned
Magnetic field	region of magnetic influence around the magnetic poles and moving charged particles
Magnetic field lines	lines showing the shape of a magnetic field. A compass placed on such a line will turn so that the needle is aligned with it because of electromagnetic induction
Magnetic force	between magnets, it is attraction of unlike magnetic poles and the repulsion between like magnetic poles; between a magnetic field and a moving charged particle, it is a deflecting force due to the motion of the particle; the deflecting force is perpendicular to both the magnetic field lines and the direction of motion
Magnetic poles	magnetic south or north seeking regions on a magnet that produces magnetic forces
Magnetism	property of being able to attract objects made of naturally occurring magnetic substances like iron, nickel, cobalt or some of its alloys
Transformer	can step-up or step-down voltages using the principles of electromagnetic induction

References and Links

Printed Materials:

Department of Education - National Science Teaching Instrumentation Center (n.d.). *User's Laboratory Manual for Physics - Student Worksheets for Secondary School Physics.* Lahug, Cebu: NSTIC.

Glencoe Physics Principles and Problems: Laboratory Manual. (Teacher ed.). New York, NY: Mc Graw-Hill Companies.

Hewitt, Paul G. (2006). *Conceptual Physics*, (10th ed). Menlo Park, California: Addison Wesley Publishing Inc.

Higgins, C. Jr., Shipman, J., Wilson, J. (2013). *An Introduction to Physical Science*. Pasig City: Cengage Learning Asia Pte. Ltd.

Littell, M. (2005). *Science Integrated Course 2.* Teacher's Edition. Evanston, Illinois: McDougal Littell.

Loo, K. W., Loo, W.Y., See, T. W. (2004). *Physics Insights*. Philippines: Pearson Education Asia Pte. Ltd.

Pople, S. (1999). *Co-ordinated science: Physics.* Walton St., Oxford: Oxford University Press.

Robinson, P. (2002). *Conceptual physics: Laboratory manual.* Upper Saddle River, NJ: Prentice-Hall, Inc.

University of the Philippines - National Institute for Science and Mathematics Education Development. (2007). *Practical work in high school physics - A sourcebook for teachers.* (2nd ed.). Diliman, Quezon City: UP-NISMED Press.

Electronic Sources:

Besse, J., Pétrélis, F., Valet, J. P. (2011, October 16). Plate tectonics may control geomagnetic reversal frequency. *Geophysical Research Letters*. [Accessed: October 29, 2014 2:23 A.M.] at http://www2.cnrs.fr/en/1923.htm

http://auto.howstuffworks.com/car-driving-safety/safety-regulatory-devices/red-light-camera1.htm [Accessed: February 27, 2014]

http://blog.dubspot.com/understanding-audio-interfaces/ [Accessed: November 1, 2014]

http://cse.ssl.berkeley.edu [Accessed: February 27, 2014]

http://education.mrsec.wisc.edu/57.htm [Accessed: July 26, 2014]

http://education.mrsec.wisc.edu/background/fridgemag/ [Accessed: July 26, 2014]

http://jedsound.com/blog/wp-content/uploads/2010/09/spk.png [Accessed: March 4, 2014] http://knowhow.com/article.dhtml?articleReference=1118&country=uk [Accessed: October 29, 2014]

http://ktrmurali.wordpress.com/2012/02/27/how-induction-cooking-works/ [Accessed: March 5, 2014]

http://lifehacker.com/5853193/how-can-i-set-up-a-home-recording-studio-on-the-cheap [Accessed: March 1, 2014]

http://micro.magnet.fsu.edu/electromag/java/detector/ [Accessed: March 5, 2014]

http://phet.colorado.edu/en/get-phet/full-install (Jan 21, 2015 version)

http://web.mit.edu/8.02t/www/802TEAL3D/visualizations/guidedtour/Tour.htm#_Toc27302305 [Accessed: July 14, 2014]

http://www.instructables.com/id/How-to-Make-a-Homopolor-Motor/ [Accessed: February 27, 2014]

http://www.magnet.fsu.edu/education/tutorials/pioneers.htm Retrieved: February 26, 2014

http://www.msichicago.org/online-science/activities/activity-detail/type/print/activities/build-an-electric-motor/ [Accessed: March 5, 2014]

http://www.music-production-guide.com/ [Accessed: March 3, 2014]

http://www.music-production-guide.com/music-production-studio.html

http://www.orientalmotor.com/technology/articles/article166-1e.html [Accessed: February 28, 2014]

http://www.space.com/22393-sun-magnetic-field-explained-infographic.html [Accessed October 29, 2014]

Woodford, C. (2008) *Metal detectors*. [Accessed February 27, 2014] at http://www.explainthatstuff.com/metaldetectors.html.

http://www.products.telecomb2b.com

http://support.image-line.com/knowledgebase/base.php?ans=231

www.digitaldjgear.com

www.nch.com.au

http://sreemediaeducation.blogspot.com/2011/08/ibps-pos-computer-awareness-mcqs.html

http://www.henrys.com/Audio-Video-Overview.aspx

http://www.hometheaterequipment.com/av-cables-76/monoprice-professional-analog-audio-cables-official-thread-1445/

http://ideas-inspire.com/simple-electric-motor/

http://www.dailygalaxy.com/photos/uncategorized/2001/03/21/earths_magnetic_field.org

Unit 2
MODULE

2

Suggested time allotment: 10 hours

ELECTROMAGNETIC SPECTRUM

I. Introduction

In Module 1, you have learned about the interrelationship between electricity and magnetism. You were able to discover how electric field could create magnetic field and vice versa.

In this module, you will learn about the different regions of the electromagnetic spectrum. This module will lead you to understand how electromagnetic waves transport energy. It also consists of activities that will enrich your understanding on the application of electromagnetic waves in our everyday living, and consequently, how these waves affect living things and the environment.

At the end of Module 2, you will be able to answer the following questions:

1. How do the regions in the electromagnetic spectrum differ in terms of wavelength, frequency and energy?
2. How do the different types of electromagnetic waves become relevant to people and environment?
3. What are the consequent effects of electromagnetic waves?

II. Learning Competencies/Objectives

1. Trace the development of the electromagnetic theory.
2. Describe how electromagnetic (EM) wave is produced and propagated.
3. Compare the relative wavelengths, frequencies and energies of the different regions of the electromagnetic spectrum.
4. Cite examples of practical applications of the different regions of EM waves.
5. Explain the effects of electromagnetic radiation on living things and the environment.

III. Pre-Assessment

A. Choose the letter of the correct answer.

1. Which two waves lie at the ends of the visible spectrum?
   a. Infrared and Ultra-violet rays
   b. Radio waves and Microwaves
   c. Radio waves and X-rays
   d. X-rays and Gamma rays

2. In the visible spectrum, which color has the longest wavelength?
   a. Blue b. Green c. Red d. Violet

3. Which property spells the difference between infra-red and ultra-violet radiation?
   a. Color
   b. Speed in vacuum
   c. Wavelength
   d. None of the above

4. A certain radio station broadcasts at a frequency of 675 kHz. What is the wavelength of the radio waves?
   a. 280 m
   b. 324 m
   c. 400 m
   d. 444 m

5. What type of electromagnetic waves is used in radar?
   a. Infrared rays
   b. Microwaves
   c. Radio waves
   d. Ultra-violet rays

B. Below are the applications of electromagnetic waves. State the type of electromagnetic wave used in each application.
   1. Camera autofocusing
   2. Radio broadcasting
   3. Diagnosis of bone fractures
   4. Sterilization of water in drinking fountains
   5. Sterilization of medical instruments

C. Answer the following question briefly but substantially.
   1. How are EM waves different from mechanical waves?
   2. Give two sources of EM waves in the Earth's environment.

IV. Reading Resources and Instructional Activities

The Electromagnetic Wave Theory

Did you send text messages to somebody today? Or have you ever tried cooking in a microwave oven? Did you know that these previously mentioned human activities make use of microwaves? Microwaves carry energy, and so with the other kinds of electromagnetic waves. But what are electromagnetic waves? How can these waves become useful to us?

For a start, let us learn how the study of the electromagnetic waves came to be.

> **Agreement:**
>
> Do a research to find out who were the proponents on the formulation of electromagnetic theory. You may use print and non-print references to gather your information. You may limit it to 5 significant scientists. Be sure to indicate your sources/references for proper acknowledgment.

The research work enabled you to gain information about the scientists who made great contribution to the development of the electromagnetic theory.

Your gathered information will be useful in accomplishing the first activity.

Activity 1

How it came about…

The Electromagnetic Wave Theory

(Adapted from APEX Physics LP Chapter 3 Lesson 3: Student Activity 3a: The Electromagnetic Theory)

Objectives:

- Match the scientists with their contributions to the development of the electromagnetic theory.
- Make comic strips of the scientists' contributions.

Materials:

- 1 white cartolina
- 1 marker pen
- 1 pencil with eraser
- coloring materials (optional)

Procedure:

I. Match the scientists given below with their contributions.

Scientists	Contributions
______1. Ampere	a. Contributed in developing equations that showed the relationship of electricity and magnetism
______2. Faraday	b. Showed experimental evidence of electromagnetic waves and their link to light
______3. Hertz	c. Demonstrated the magnetic effect based on the direction of current
______4. Maxwell	d. Formulated the principle behind electromagnetic induction.
______5. Oersted	e. Showed how a current carrying wire behaves like a magnet

II. Using the information you gathered previously, make a concept web/ comic strips of the contributions of the following scientists.

A. Ampere
B. Faraday
C. Hertz
D. Maxwell
E. Oersted

Guide Questions:

Q1. What new insights/learning did you get about our natural world? How did it change your view about light?

You are about to explore the unknown world of EM spectrum. Read and research for more scientists who made significant contributions in the development of the study on the EM spectrum.

The Electric and Magnetic Fields Together

Accelerating electrons produce electromagnetic waves. These waves are a combination of electric and magnetic fields. A changing magnetic field produces an electric field and a changing electric field produces a magnetic field. As accelerated electrons produce an electric field of a wave, the varying electric field produces the wave's magnetic field. Both the electric field and the magnetic field oscillate perpendicular to each other and to the direction of the propagating wave.

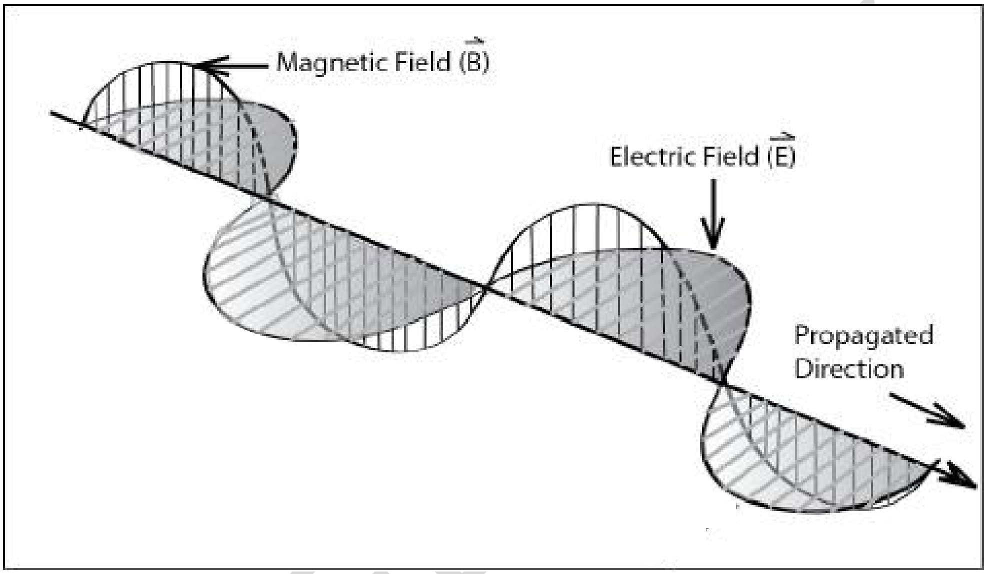


Figure 1. Electromagnetic Wave

All electromagnetic waves can travel through a medium but unlike other types of waves, they can also travel in vacuum. They travel in vacuum at a speed of $3X10^8$ m/s and denoted as c, the speed of light. The wave speed, frequency, and wavelength are related by the following equation:

$$v=\lambda f$$

where ***v*** is the wave speed, or ***c*** (speed of light) expressed in meters per second, the frequency ***f*** is expressed in Hertz and the wavelength ***λ*** is expressed in meters.

Since all the EM waves have the same speed and that is equal to the speed of light, as wavelength decreases, the frequency of the wave increases.

Through the years, the advancement on the knowledge about electromagnetic waves led us to a modern technological world.

Example Problems:
(Assume that the waves propagate in a vacuum.)

1. What is the frequency of radio waves with wavelength of 20 m?

Given: $v = c = 3X10^8$ m/s
$\lambda = 20$ m
f= ?

$v = c = \lambda f$

$\mathbf{f = c/\lambda}$

$= \dfrac{3X10^8 \text{ m/s}}{20 \text{ m}}$

$= 1.5 \text{ X}10^7$ Hz

2. What is the frequency of light waves with wavelength of $5 \text{ X } 10^{-7}$ m?

Given: $v = c = 3X10^8$ m/s
$\lambda = 5 \text{ X } 10^{-7}$ m
f= ?

$v = c = \lambda f$

$\mathbf{f = c/\lambda}$

$= \dfrac{3X10^8 \text{ m/s}}{5X10^{-7} \text{m}}$

$= 6 \text{ X}10^{14}$ Hz

Check your understanding!
Are these statements true? If not, correct them.

1. Electromagnetic waves transfer energy through vacuum.
2. A wave is a disturbance that transfers energy.
3. Most EM waves are invisible and undetectable.

The Electromagnetic Spectrum

The electromagnetic spectrum is a continuum of electromagnetic waves arranged according to frequency and wavelength. It is a gradual progression from the waves of lowest frequencies to the waves of highest frequencies. According to increasing frequency, the EM spectrum includes: radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays. These waves do not have exact dividing region.

The different types of electromagnetic waves are defined by the amount of energy carried by/possessed by the photons. Photons are bundles of wave energy. The energy of a photon is given by the equation:

$$\boldsymbol{E = hf}$$

where *h* is the Planck's Constant and *f* is the frequency of the EM wave. The value of the Planck's constant is $6.63 \text{ x } 10^{-34}$ joules per second.

From among the EM waves, the gamma rays have photons of high energies while radio waves have photons with the lowest energies.

With regards to wavelength, radio waves can be likened to the size of a football field while gamma rays are as small as the nuclei of an atom.

Figure 2 will give you a clearer idea of the characteristics of the electromagnetic waves as their sizes are compared with visible materials.

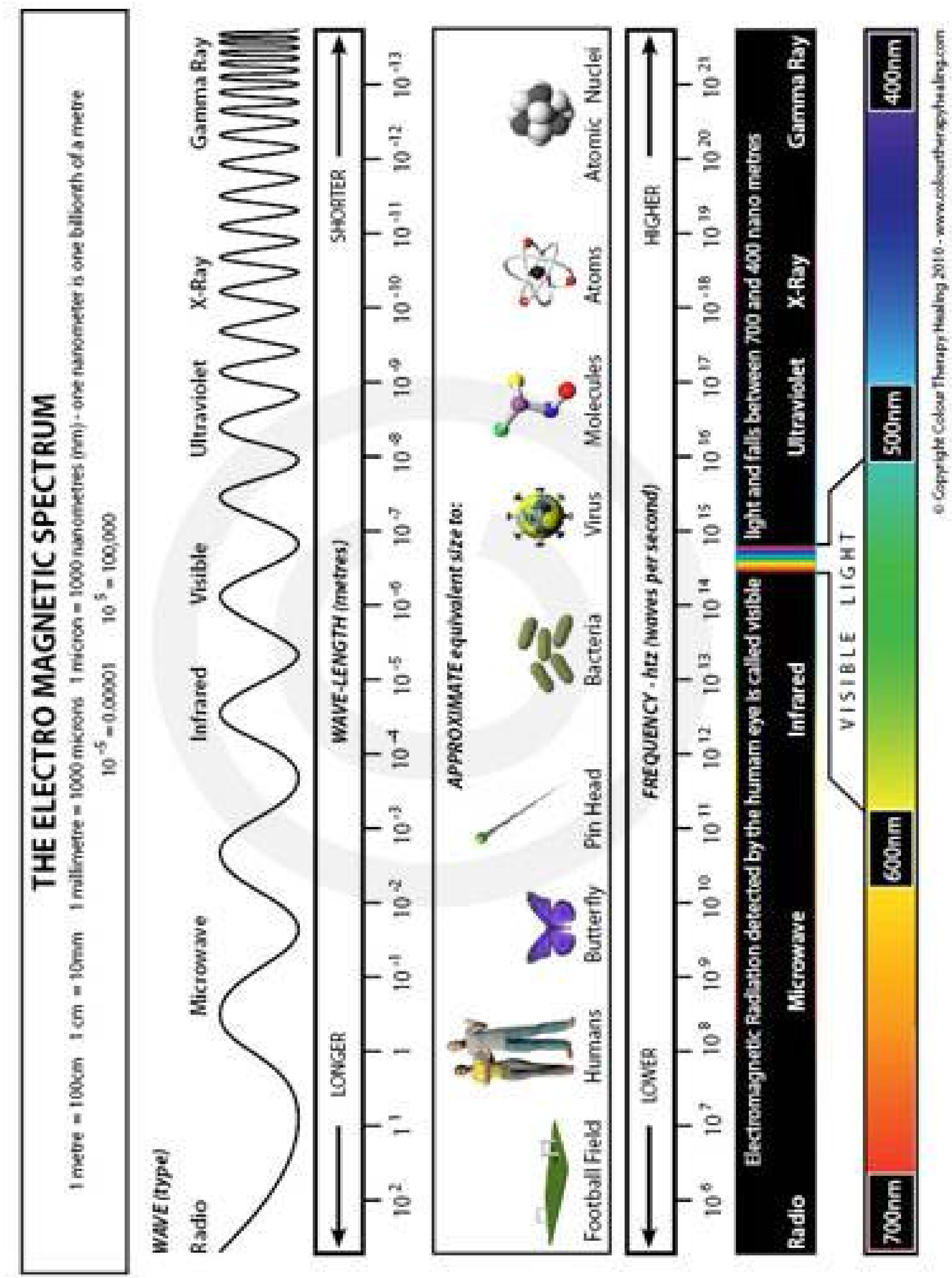


Figure 2. The Electromagnetic Spectrum

Table 1 shows the relative wavelength, frequency, and energy of each of the different types of electromagnetic waves.

Table 1. The electromagnetic waves' wavelengths, frequencies, and energies

EM Wave	Wavelength (m)	Frequenzy (Hz)	Energy (J)
Radio	> 1×10^{-1}	< 3×10^{9}	< 2×10^{-24}
Microwave	1×10^{-3} -1×10^{-1}	3×10^{9} - 3×10^{11}	2×10^{-24} - 2×10^{-22}
Infrared	7×10^{-7} - 1×10^{-3}	3×10^{11} - 4×10^{14}	2×10^{-22} - 3×10^{-19}
Visible	4×10^{-7} - 7×10^{-7}	4×10^{14} - 7.5×10^{14}	3×10^{-19} - 5×10^{-19}
UV	1×10^{-8} - 4×10^{-7}	7.5×10^{14} - 3×10^{16}	5×10^{-19} - 2×10^{-17}
X-ray	1×10^{-11} - 1×10^{-8}	3×10^{16} - 3×10^{19}	2×10^{-17} - 2×10^{-14}
Gamma-ray	< 1×10^{-11}	> 3×10^{19}	> 2×10^{-14}

After learning about the wavelengths and frequencies of the different types of EM waves, try this next activity to learn more on other characteristics of EM waves.

Activity 2

Now you go! Now you won't!

Adapted from: http://www.sciencebuddies.org/

Objectives:

- Identify materials that can block or allow radio waves to pass through.
- Compare the speed of EM waves through different materials.

Materials:

Remote controlled (RC) Car and controller (both with new batteries)
Different materials to test:

- Aluminum foil
- Plastic wrapper
- Paper
- Wax paper
- Cotton
- Rubber gloves

A wide open space to test drive your RC car.

Procedure:

1. Wrap the antenna of the RC car and of the receiver with the first material you want to test, using several layers so that they are completely and securely covered.

2. Attempt to operate the RC car using the remote control. Does it work?

3. Use a stopwatch to time your test drive over a set distance.

4. Repeat steps 1 to 3 using other materials. Make sure to maintain the distance between the RC car and the remote control. Collect data in a table similar to the table below.

Set Distance: _______________

Material	Does the car work? (Y/N)	Time of Travel	Observations
aluminum foil			
plastic wrapper			
paper			
wax paper			
cotton			
rubber glove			

5. Divide the materials into good and poor transmitters based on your results.

Guide Questions:

Q2. Compare the time taken by the RC car to cover the same distance. Do some go faster or slower?

Q3. What does this tell you about the transmission of the signal?

Q4. What characteristic of EM waves did you discover?

Radio Waves

Radio waves have the longest wavelength in the electromagnetic spectrum. They are produced by making electrons vibrate in an antenna. They are used to transmit sound and picture information over long distances.

Figure 3. A radio

Radio waves have a very wide range of wavelengths. The whole region of the radio waves is divided into smaller regions or wavebands. Each waveband is allocated by law to a specific radio service. The wavelengths and frequencies of the different wavebands and their uses are shown in Table 2.

Table 2. Radio waves Frequencies

BAND	Frequency Range	Wavelength Range	Application
Extremely Low Frequency (ELF)	< 3 kHz	> 100 km	
Very Low Frequency (VLF)	3-30 Hz	10-100 km	
Low Frequency (LF)	30-300 kHz	1-10 km	Radio communication
Medium Frequency (MF)	300 kHz – 3 MHz	100m – 1 km	Radio communication (AM radio broadcasting)
High Frequency (HF)	3 – 30 MHz	10 – 100 m	Radio communication (AM radio broadcasting)
Very High Frequency (VHF)	30 – 300 MHZ	1 – 10 m	Radio communication (FM radio broadcasting) TV Broadcasting
Ultra High Frequency (UHF)	300 MHz – 3 GHz	10 cm – 1 m	Radio communication (FM radio broadcasting) TV Broadcasting
Super High Frequency (SHF)	3 – 30 GHz	1 – 10 cm	Radio communication Satellite Communication
Extremely High Frequency (EHF)	30 – 300 GHz	1mm – 1 cm	

Low frequency waves are suitable for communication over great distances. But the curvature of the earth limits the range to about 80 kilometers. To extend the range, a repeater is used. The repeater receives the signal and re-transmits it to the receiving station.

High frequency waves can be reflected by the ionosphere. This enables the waves to be transmitted over great distances.

Medium and high frequency waves are used for broadcasting by local radio stations. In a radio station, sound is converted by a microphone into patterns of electric current variations called audio-frequency (AF) signals. High frequency radio waves called radio-frequency (RF) carriers can be modulated to match the electronic signal. In amplitude modulation, the amplitude of the radio waves (RF carrier) changes to match that of the audio-frequency signal. This is used in standard broadcasting because it can be sent over long distances. Very high frequency waves provide a higher quality broadcasting including stereo sound. In this process, instead of the amplitude of the RF carrier, it is the frequency of the waves that changes to match that of the signal. This is called frequency modulation.

Try the next activity to learn about the production, transmission and reception of radio waves.

Activity 3

Sound check…

Adapted from: Littell, McDougal Science. Integrated Course 1, Teacher's edition. McDougal Littell, a division of Houghton Mifflin Company C79.

Objectives:

- Produce radio waves.
- Detect radio waves.

Materials:

- Two - 25 cm copper wire
- C or D battery
- electrical tape
- metal fork
- portable radio

Procedure:

1. Tape one end of the first wire to one end of the battery. Tape one end of the second wire to the other end of the battery.

2. Wrap the loose end of one of the wires tightly around the handle of the fork.

3. Turn on the radio to the AM band and move the selector past all stations until you reach static.

4. Hold the fork close to the radio. Stroke the free end of wire across the fork's prongs.

5. At a distance of 15 cm from the radio stroke again the free end of the wire across the forks' prongs.

6. Repeat step 5 at a distance 20 cm from the radio.

Guide Questions:

Q5. What happens when you stroke the prongs with the wire?

Q6. How does changing the position affect the results?

Q7. What might be the cause when you sometimes hear static sound in your radio? What can be done to resolve it?

Activity 4

Then there was sound…

Adapted from: APEX Physics LP Chapter 3 Lesson 4: Student Activity 5: The Generation, Transmission, and Reception of Radio Waves

Objectives:

- Describe how radio waves are generated, transmitted, and received.
- Name the parts of the radio transmitter and receiver and give the functions of each part.

Materials:

- 2 sheets of Manila paper
- sticky tape or paste
- 2 envelopes containing a word or phrase written in color-coded pieces of paper:
  light blue ⟶ *parts of the transmitter/receiver*
  pink ⟶ *waves*
  white ⟶ *linkages*

Procedure:

1. Open the envelope labeled transmitter. Arrange the strips of paper in the order at which carrier waves are produced and then transmitted.

   Blue Strips
   Oscillator, microphone, modulator, amplifier, broadcast antenna, receiver antenna

Pink Strips
Sound waves, carrier, audio, amplified modulated carrier wave, modulated radio

White strips
Are fed to the (2 pieces); Generates (2 pieces); Are picked up by; Are sent to the; Increase the energy of the carrier waves and become; Transform sound waves to electrical signal then to; Put out the modulated carrier waves and pass them to the…

2. Once you are already sure of the arrangement, paste the strips on the Manila paper, leaving gaps between them.

3. Draw arrows between strips of paper to show the route of the sound and carrier waves in the transmitter. Then choose the correct linkages.

4. Open the envelope labeled receiver and arrange the strips of paper on the other Manila paper according to how the transmitted waves are received.

5. Follow the same procedure as in steps 2 and 3.

   Blue strips
   tuner; receiver antenna; amplifier; demodulation; loudspeaker

   Pink strips
   frequency of the weak modulated carrier waves; sound signals and carrier waves; sound; sound

   White strips
   Passes the (3 pieces); Then to; Selects the; Converts sound signal to; Removes the carrier waves leaving only the; Increases the energy of.

6. Show the continuous transmission of waves through directional arrows.

7. Post your finished work on the board and explain.

Guide Questions:

Q8. What common problems could arise during transmission and reception of radio waves? Explain the possible cause/s of those problems.

Microwaves

Microwaves have smaller wavelengths than radio waves. They are used in satellite communications, radar, television transmission and cooking.

Applications of Microwaves

Satellite Communications

Microwaves can penetrate the atmosphere of the earth. This is the reason why they are used for satellite communications. Communication satellites travel around the earth at an altitude of 35, 000 km above the equator. They move at a speed of 11 300 km/h and revolve around the earth every 24 hours, the same rate as the rotation of the earth. This makes them appear to be stationary when seen on Earth. Antennae are mounted to point in fixed directions towards these satellites. Microwaves signals are transmitted by an antenna to a satellite which amplifies and re-transmits the signal to an antenna in other parts of the world. This is how we communicate with the rest of the world.

http://www.esa.int/Our_Activities/Navigation/Galileo_satellite_set_for_new_orbit

Figure 4. An orbiting satellite

Radar

http://phys.org/news/2013-03-nasa-kaboom-experimental-asteroid-radar.html

Figure 5. A radar

Microwaves have short wavelengths and are reflected by small objects. This property is used in radars. Radar is the acronym of radio detection and ranging. A radar system is consists of an antenna, transmitter, and a receiver. The antenna whirls around continuously to scan the surrounding area. The transmitter sends out a narrow beam of microwaves in short pulses. A distant object reflects some of the signal back to the receiver. The direction to which the signal was received gives the direction of the object. The distance of the object can be calculated from the time lag between the transmitted pulse and the reflected pulse.

Figure 6. A Television set

Terrestrial Communication

Microwaves are used to transmit television news coverage from mobile broadcast vehicles back to the station. The news crew can also set up a small antenna to send signals to a communication satellite. This is how news are broadcasted and watched live around the world.

A cell phone is a radio transmitter and receiver that uses microwaves. Cellular phones depend on overlapping network of cells or areas of land several kilometres in diameter. Each cell has its tower that receives and sends microwave signals. The figure below will give you further understanding on the process.

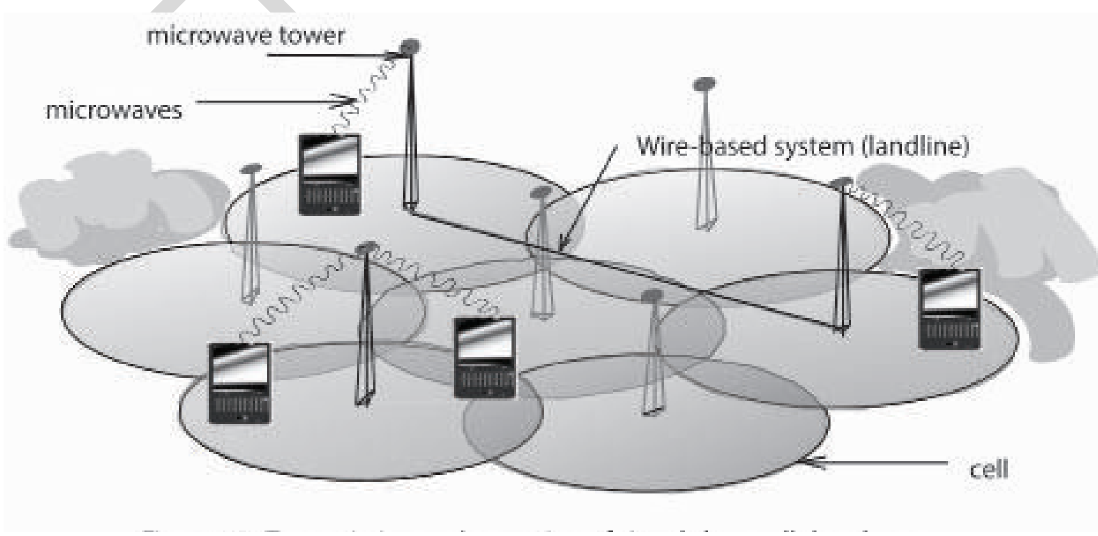


Figure 7. Transmission and reception of signals by a cellular phone

Microwave oven

In a microwave oven, foods absorb certain microwave frequencies very strongly. The microwaves penetrate the food being heated. It will agitate the water molecules within the food, thus creating molecular friction which then produces heat that will cook it.

http://linmabeltech.com/?attachment_id=885

Figure 8. A microwave oven

The next activity will give you an idea about the next type of EM wave, the infrared wave.

Activity 5

It's getting hotter

Objectives:

- Discover infrared and its effect.
- Explain the relationship between frequency and the energy carried by an EM wave.

Materials:

- prism
- 3 alcohol thermometers with blackened bulb
- sunlight

Procedure:

1. This experiment must be done in sunlight.
2. Take the initial readings of the three thermometerse while in the shade. Record your readings in a data table similar to the table below.
3. Let the sunlight pass through the prism to split the sun's white light into its component colors.
4. Position one thermometer in the blue region.
5. Position another thermometer in the yellow region.
6. Position the last thermometer just below the red region.

7. Measure the temperature every after 2 minutes for 10 minutes.
8. Record the temperature readings in the three regions in the table below.

Time	Temperature Readings		
	1st Thermometer (Blue Region)	**2nd Thermometer (Yellow Region)**	**3rd Thermometer (Red Region)**
0			
2 minutes			
4 minutes			
6 minutes			
8 minutes			
10 minutes			

Guide Questions:

Q9. Did you see any trend? Explain if there is any.

Q10. What did you notice about the temperature readings?

Q11. In which region have you recorded the highest temperature after 10 minutes?

Q12. What do you think exists just beyond the red part of the spectrum?

Q13. Discuss any other observations or problems.

Infrared

Infrared radiation lies beyond the red end of the visible light. It is emitted by all objects. The amount and wavelength of radiation depend on temperature. Below 500oC, an object emits only infrared radiation. Above 500oC, an object glows and emits both infrared and some visible light.

Our bodies radiate infrared and under infrared camera or a night vision goggle, our images appear in variety of colors. The differences in color determine the differences in temperature. For example, shades of blue and green indicate regions of colder temperature; and red and yellow indicate warmer temperature.

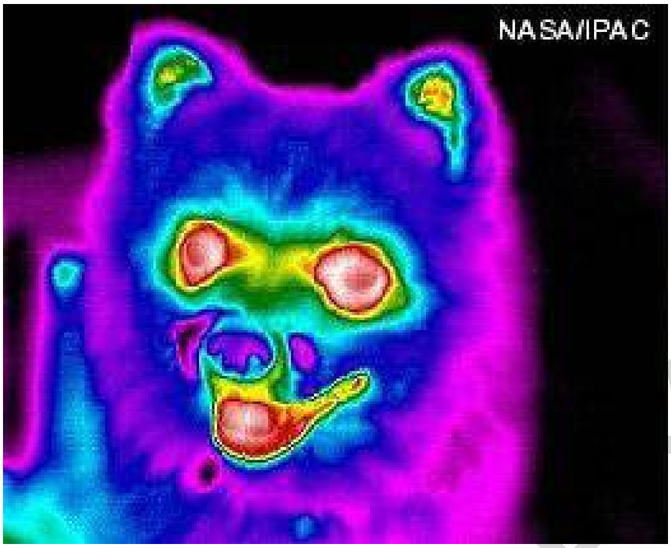


Figure 9. Infrared image of a dog

In Figure 9, the dog is covered with thick coat of fur that prevents the heat generated by the dog's body from escaping. Notice that the dog's nose is cold while the eyes and mouth areas are warm.

The following are some useful applications of IR radiation:

1. Infrared photographs taken from a satellite with special films provide useful details of the vegetation on the Earth's surface.
2. Infrared scanners are used to show the temperature variation of the body. This can be used for medical diagnosis.
3. Infrared remote controls are used in TVs, video, cassette recorders, and other electronic appliances.
4. Some night-vision goggles use IR.
5. Some autofocus cameras have transmitter that sends out infrared pulses. The pulses are reflected by the object to be photographed back to the camera. The distance of the object is calculated by the time lag between the sending and receiving of pulses. The lens is then driven by a built-in motor to adjust to get the correct focus of the object.

The Visible Spectrum

When white light passes through a prism, it is separated into its constituent colors: the red, orange, yellow, green, blue, indigo and violet. These colors do not distinctly separate but they continuously change from red to violet. Red color has the longest wavelength from among these colors and violet has the shortest.

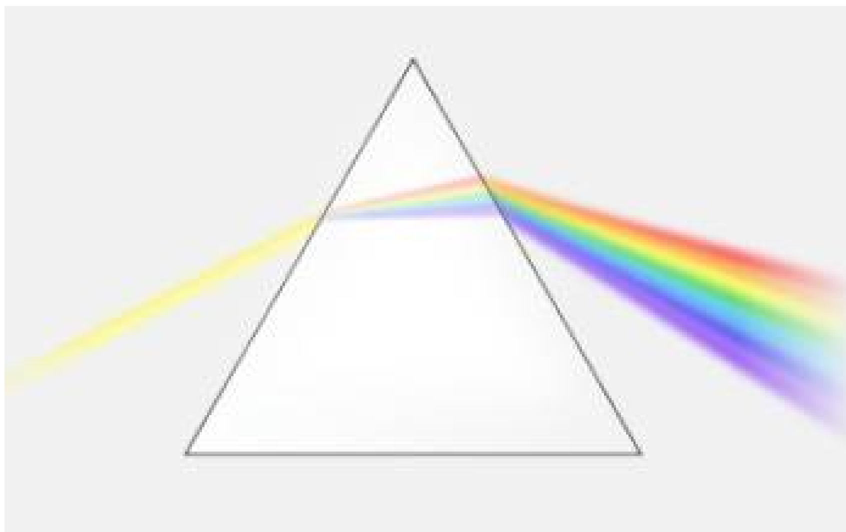


Figure 10. The Visible Spectrum

Our eyes are sensitive to electromagnetic waves of wavelengths that ranges from 4×10^{-7} m to 7×10^{-7} m. This is the range of wavelengths of white light. Thus, the spectrum of white light is therefore called the visible spectrum. Table 3 shows the wavelengths of the different colors that constitute the white light.

Table 3. The Wavelength of the Different Colors of Light

Color	Wavelength (nm)
Violet - Indigo	390 to 455
Blue	455 to 492
Green	492 to 577
Yellow	577 to 597
Orange	597 to 622
Red	622 to 700

The next activity introduces the next part of the electromagnetic spectrum. Perform this activity to have a deeper understanding about this kind of EM wave. This activity should be done early in the morning so as to expose the material throughout the day.

Activity 6

Screen the UV out

Objectives:
- Block UV rays of the sun.
- Discover the effects of UV rays.

Materials:
- Ziploc snack bag
- newspaper
- sunscreen/sunblock
- black construction paper
- permanent marker

Procedure:
1. Cut a piece of newspaper to fit snugly inside a Ziploc snack bag.
2. Outside the snack bag, draw two lines with a marker dividing the bag into three equal parts from the top of the bag to the bottom.
3. Apply a thin coat of sunscreen in the leftmost part.
4. Cover the middle part with black construction paper.
5. The right part should be left fully exposed.
6. Place the snack bags in a place fully exposed to sunlight.
7. Recover the snack bags in the afternoon.

Guide Questions:

Q14. How does the newsprint vary in the three divisions of the newspaper?

Q15. What does this indicate?

Q16. How does this realization impact to your personal life?

Extension Activity: For a more noticeable result, continue exposing the material for several days.

Perform the same activity during a cloudy day or inside the house. Observe and compare the degree of effect to that during a bright sunny day.

Ultraviolet Radiation

Ultraviolet radiation lies just beyond the violet end of the visible spectrum. Ultraviolet waves have shorter wavelengths than the visible light and carry more energy.

Some Uses of UV Radiation

The sun is our main source of ultraviolet radiation but there are also artificial sources of UV light. Ultraviolet radiation in UV lamps are used by banks to check the signature on a passbook. The signature is marked on the passbook with fluorescent ink. It becomes visible when viewed under an ultraviolet lamp. These lamps are also used to identify fake banknotes.

Ultraviolet radiation is also used in sterilizing water from drinking fountains. Some washing powder also contains fluorescent chemicals which glow in sunlight. This makes your shirt look whiter than white in daylight.

Ultraviolet radiation in sunlight produces vitamin D in the skin and gives us tanning effect. But since UV rays have high energy, it could be harmful to some extent. It could burn the skin and hurt our eyes. Overexposure to UV radiation may cause skin cancer. Suntan or sunscreen lotions serve as filters to protect the body from ultraviolet radiation.

X-rays

X-rays come just after the ultraviolet rays. They are of shorter wavelength but carries higher energy than the UV.

Figure 11. An X-ray film

X-rays are produced using an X-ray tube. They are emitted when fast moving electrons hit a metal target. X-rays were discovered by Wilhelm Conrad Roentgen in 1895.

Long wavelength X-rays can penetrate the flesh but not the bones. They are used in X-ray photography to help doctors look inside the body. They are useful in diagnosing bone fractures and tumors.

Short wavelength X-rays can penetrate even through metals. They are used in industry to inspect welded joints for faults.

All X-rays are dangerous because they can damage healthy living cells of the body. This is the reason why frequent exposure to X-rays should be avoided. Too much exposure to X-rays can damage body tissues and can cause cancer.

Gamma Rays

Gamma rays lie at the other end of the electromagnetic spectrum. They are shortest in wavelength and highest in frequency. They carry the highest amount of energy, thus, they are more dangerous. Gamma rays are emitted by stars and some radioactive substances. They can only be blocked with lead and thick concrete.

Gamma rays are very strong that they can kill living cells. Gamma rays are used to treat cancer through the process called radiotherapy. They are also used for sterilization of drinking water.

V. Summary/Synthesis/Feedback

- A wave is a disturbance that transfers energy.
- James Clerk Maxwell formulated the Electromagnetic Wave Theory which says that an oscillating electric current should be capable of radiating energy in the form of electromagnetic waves.
- Heinrich Hertz discovered the Hertzian waves which is now known as radio waves.
- Hertz is the unit used to measure the frequency of waves.
- Electromagnetic (EM) waves have unique properties.
    - ► EM waves can travel through a vacuum.
    - ► EM waves travel at the speed which is constant in a given medium and has a value of c = 3.0 x 108 m/s in vacuum.
    - ► EM waves are disturbances in a field rather than in a medium.
    - ► EM waves have an electric field that travels perpendicular with the magnetic field.
    - ► EM waves form when moving charged particles transfer energy through a field.
- Most EM waves are invisible to the eye but detectable. Only the visible light is seen by humans.
- Waves in the EM spectrum include the following from the longest wavelength to the shortest wavelength.
    - ► Radio waves
    - ► Microwaves
    - ► Infrared waves
    - ► Visible light
    - ► Ultraviolet
    - ► X-rays
    - ► Gamma rays

The order also shows the increasing frequency and energy of the EM waves.

- The waves in the various regions in the EM spectrum share similar properties but differ in wavelength, frequency, energy, and method of production.
- The regions in the EM spectrum have various uses and applications as follows:

EM Wave	Applications / Uses
Radio waves	Radio and television communication
Microwaves	Satellite television and communication
Infrared waves	Remote control, household electrical appliances
Visible light	Artificial lighting, optical fibers in medical uses, screen of electronic devices
Ultraviolet	Sterilization, Fluorescence
X-rays	Medical use, engineering applications
Gamma rays	Medical treatment

- Each type of EM wave poses a certain degree of risk and danger to people and environment.

VI. Summative Assessment

A. Multiple Choice. Choose the letter of the correct answer.

1. Which electromagnetic wave carries more energy than the others?
   a. microwaves
   b. radio waves
   c. UV radiation
   d. visible light

2. What electromagnetic wave is sometimes called heat rays?
   a. gamma rays
   b. infrared
   c. radio waves
   d. visible light

3. What is the frequency range of UV radiation?
   a. 3.5×10^{9} -3×10^{11} Hz
   b. 3.5×10^{11} - 3×10^{114} Hz
   c. 7.5×10^{14} - 3×10^{16} Hz
   d. 7.5×10^{16} - 3×10^{19} Hz

4. What is the range of frequencies are our eyes sensitive to?
   a. 3×10^{9} - 3×10^{11} Hz
   b. 3×10^{11} - 4×10^{14} Hz
   c. 4×10^{14} - 7.5×10^{14} Hz
   d. 7.5×10^{14} - 3×10^{16} Hz

5. What is the wavelength of the wave with a frequency of 3 x 109 Hz?
   a. 1.0×10^{-1} m
   b. 1.0×10^{1} m
   c. 1.0×10^{-2} m
   d. 1.0×10^{2} m

B. Below are the applications of electromagnetic waves. State the type of electromagnetic wave used in each application.

1. Satellite communications
2. Texting
3. TV broadcasting
4. Radar
5. Checking bankbook signature

C. Answer the following questions briefly.

1. Describe the mathematical relationship between frequency and wavelength.
2. What is the function of a tower in cell phone operation?
3. What does a radio transmitter do?
4. How can infrared radiation be detected if cannot be seen?
5. Why are high frequency electromagnetic waves like gamma rays harmful to living things?

Glossary of Terms

Electromagnetic wave	a disturbance in a field that carries energy and does not require a medium to travel
Frequency	number of cycles a wave completes in one second; expressed in Hertz
Radar	short for radio detecting and ranging. A way of detecting aircrafts and ships from a distance and estimating their locations
Radio Receivers	receives radio waves and convert them back to sounds
Radio Transmitter	attaches information to the radio signal by modulating it
Wavelength	the distance measured from one crest of a wave to the next crest or from one through to the second through

References and Links

Printed Materials:

Glencoe Physics Principles & Problems. The McGraw-Hill Companies, Inc., 2013

Kirkpatrick et. al. Physics: A World View, International Student Edition. The Tomson Corporation, 2007.

Littell, McDougal. Science, Integrated Course 1, Teacher's Edition. Evanston, Illinois: McDougal Littell, 2005.

Padua, AL., Crisostomo RM., Practical and Explorational Physics Modular Approach. Vibal Publshing House, Inc., Copyright 2003

Yong, et al. Physics Insights, Low Price Edition. Jurong, Singapore: Pearson Education (Asia) Pte Ltd.

Electronic Sources:

http://www.imaginationstationtoledo.org

http://www.can-do.com/uci/ssi2001/emspectrum.html

http://www.physicsclassroom.com/mmedia/waves/em.cfm

http://science.hq.nasa.gov/kids/imagers/ems/ems2.html

http://www.scienceinschool.org/2009/issue12/microwaves

http://enviroadvocacy.com/measure-your-campaign/

http://sciencevault.net/11hscphys/82worldcommunicates/823%20em%20waves.htm

http://www.colorado.edu/

http://school.discoveryeducation.com/lessonplans/interact/electromagneticspectrum.html

http://www.sciencebuddies.org/

http://webs.mn.catholic.edu.au/science/wilko/is94/notes/no2.htm

http://www.esa.int/Our_Activities/Navigation/Galileo_satellite_set_for_new_orbit

http://phys.org/news/2013-03-nasa-kaboom-experimental-asteroid-radar.html

http://linmabeltech.com/?attachment_id=885

Suggested time allotment: 15 hours

Unit 2
MODULE
3

LIGHT: MIRRORS & LENSES

I. Introduction

In the previous module, you learned about electromagnetic spectrum. You gained an understanding of the different electromagnetic waves and their benefits. One of the most common among these electromagnetic waves is the visible light.

In this module, you will study two of the properties of visible light - reflection and refraction. A closer look into these properties will be done through different observable examples and experimentations using mirrors and lenses. As you walk through the pages of this module, you will be able to use the laws of reflection and refraction in order to describe and explain how images are formed by mirrors and lenses. You will also be able to solve problems pertaining to the position and magnification of images formed by mirrors and lenses.

One of the thrusts of this module is to make you aware of the purposes of the different types of mirrors and lenses so you can select the right type of mirrors and lenses that you can use in your daily lives.

At the end of Module 3, you will be able to answer the following questions:

1. How do the laws of reflection and refraction explain the functions of some optical instruments?
2. How does changing the location of the object from the lens/mirror affect the image formed?
3. How does changing the focal length of the lens/curved mirror affect the image formed?

II. Learning Competencies/Objectives

1. Predict the qualitative characteristics (location, orientation, type, and magnification) of images formed by plane and curved mirrors and lenses.
2. Determine the quantitative characteristics (location, orientation, type, and magnification) of images formed by plane and curved mirrors. and lenses.
3. Distinguish between converging and diverging mirrors and lenses.
4. Apply ray diagramming techniques in describing the characteristics and positions of images formed by mirrors and lenses.
5. Derive the mirror and lens equations.
6. Identify ways in which the properties of mirrors and lenses determine their use in optical instruments (e.g., cameras and telescopes).

III. Pre-Assessment

Directions. Choose the letter of the correct answer.

1. You see the reflection of the clock without numbers in your plane mirror. The image formed by the hands of the clock shows the time of 3:30. What is the real time?
   a. 3:30
   b. 8:30
   c. 9:30
   d. 10:30

2. How much larger will your classroom seem to appear if the entire two adjacent walls of your classroom consist of plane mirrors?
   a. 2x larger
   b. 3x larger
   c. 4x larger
   d. can't be determined

3. Where is the image located if an object is 30 cm in front of convex mirror with a focal length of 20 cm?
   a. Between F and V
   b. Between C and F
   c. In front of the mirror
   d. Can't be determined

4. What is the distance of your image from you if you stand 1.5m in front of a plane mirror?
   a. 1.5 m
   b. 2.0 m
   c. 3.0 m
   d. 4.5 m

5. Zed stands 1.5-m tall in front of a plane mirror. What is the height of his image?
   a. 4.5 m
   b. 3.0 m
   c. 2.0 m
   d. 1.5 m

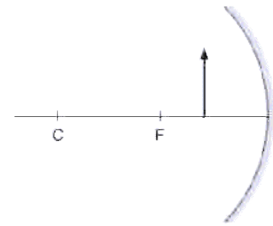
6. A light ray, traveling parallel to a concave mirror's axis, strikes the mirror's surface. The reflected ray __________.
   a. passes through the mirror's focal point
   b. again travels parallel to the mirror's axis
   c. travels at right angles to the mirror's axis
   d. passes through the mirror's center of curvature

7. An object is placed between a concave mirror and its focal point. What is the type and orientation of the image formed?
   a. virtual and inverted
   b. real and inverted
   c. virtual and erect
   d. real and erect

8. What kind of mirror is used in automobiles and trucks to give the driver a wider area and smaller image of traffic behind him?
   a. Plane mirror
   b. Convex mirror
   c. Concave mirror
   d. None of the above

9. What type of mirror do dentists usually use to see clearly the images of our teeth?
   a. Plane mirror
   b. Convex mirror
   c. Concave mirror
   d. None of the above

10. When a small object is placed on the principal axis of a concave mirror between the focus and the mirror (as in the figure below), the image formed is ____________.



a. erect, magnified, and virtual
b. inverted, magnified, and real
c. inverted, reduced, and real
d. erect, reduced, and real

11. A white sheet of paper cannot act as mirror because it ____________ the rays of light.
a. diffracts
b. diffuses
c. interferes
d. refract

12. You see your face clearly if you look down on a pool of still water. Which one of the following statements gives the best explanation for this observation?
a. Light entering the water is dispersed.
b. Regular reflection of light happens on the surface of still water.
c. Irregular reflection of light happens on the surface of still water.
d. Light is reflected from the surface of water in different directions.

13. Where should the object be placed in front of a concave mirror to form a virtual and magnified image?
a. At the focus
b. At the center of curvature
c. Between the focus and the vertex
d. Between the center of curvature and focus

14. Which of the following is/are true of a concave mirror?
I. It will never form a real image
II. An inverted image will be formed if the object distance is greater than the focal length
III. An object can be magnified if placed at f

a. I only
b. II only
c. I and II
d. I, II, and III

15. A light ray, traveling parallel to a concave lens' axis and strikes the lens, will refract and__________.
    a. pass through the lens' focal point
    b. travel parallel to the principal axis
    c. continue to travel in the same direction
    d. travel at right angles to the principal axis

16. What kind of image is formed by concave lenses?
    a. always real
    b. always virtual
    c. could be real or virtual; depends on the distance of the object from the focal point
    d. could be real or virtual, but always real when the object is placed at the focal point

17. Sun's rays are observed to focus at a point behind a lens. What kind of lens was used?
    a. Converging Lens
    b. Diverging Lens
    c. Focusing Lens
    d. None of the above

18. This optical instrument uses 2 convex lenses to make a smaller object larger.
    a. Camera
    b. Microscope
    c. Oscilloscope
    d. Telescope

19. Which of the following optical instruments will be used to produce a reduced and inverted image of a distant object?
    a. Camera
    b. Projector
    c. Microscope
    d. Refracting Telescope

20. A photocopy "Xerox" machine produces an image that is of equal size as the object. Considering the location of an object in a convex lens, where is the object located or placed to produce an image that is of equal size to the object?
    a. At F'
    b. At 2F'
    c. Between F' and V
    d. Between 2F' and F'

IV. Reading Resources and Instructional Activities

Reflection of Light in Mirrors

Have you noticed the word “AMBULANCE” in an ambulance car? How is it written? Did you ever wonder why it is written that way? You will find the answers to these questions as you go through this module. Try the following activity to study one of the properties of light.

Activity 1

Mirror, mirror, on the wall…

Objectives:

- Determine the height, width, and the distance from the mirror of the image formed by plane mirrors.
- Compare the actual height, width and the distance from the mirror of the object with that of the image formed by plane mirror.

Materials:

- 1 (10 cm x 15 cm) plane mirror
- 1 graphing paper
- 10 one–peso coins
- modeling clay
- pen

Procedure:

1. Let the mirror stand vertically along a line on a graphing paper as shown in Figure 1. Use the modeling clay to support the plane mirror.

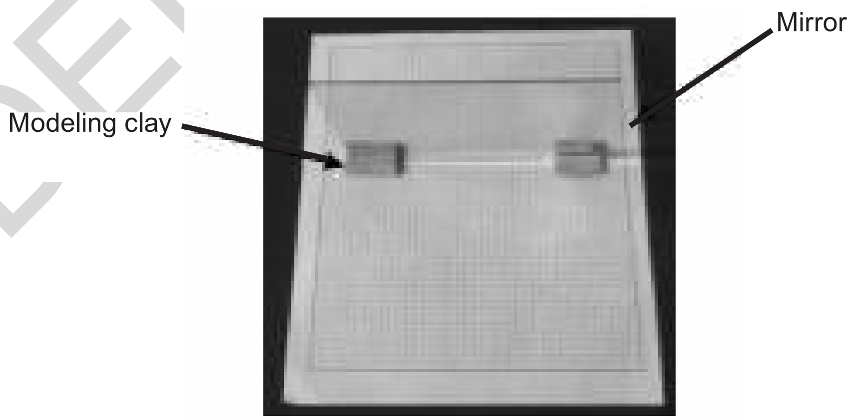


Figure 1. A Plane Mirror on a Graphing Paper.

2. Using a pen, make three (3) different marks along the intersections on the graphing paper in front of a mirror.

3. Measure the distance of each mark from the mirror by counting the number of parallel lines between the mark and the base of the plane mirror. Record your data in a table similar to Table 1 below.
4. Look at the images of the marks formed by the mirror. Measure the distance of each image from the mirror by counting the number of parallel lines between the image and the base of the mirror. Record this also in Table 1.

Table 1. Distance of the Object and Image from the Mirror

Mark	Number of Parallel Lines	
	Between the Mark and the Mirror	Between the Image and the Mirror
Mark 1		
Mark 2		
Mark 3		

Q1. Refer to Table 1, compare the distance (number of parallel lines) from the mirror of the object with that of the image.

5. Stack 10 pieces of one-peso coin in front of the plane mirror as in Figure 2. Using a ruler, measure the height and width of the stack of coins. Measure also the height and width of the image as seen on the mirror. Enter your measurements in a table similar to Table 2.

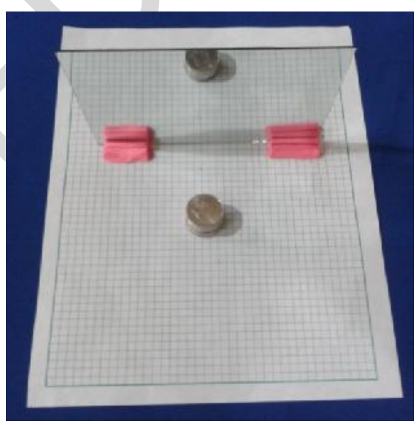


Figure 2. Stack of Coins In front of the Plane Mirror

Table 2. Height and Width of Object and Image

Description	Object	Image
Height (cm)		
Width (cm)		

Q2. How do the height and width of the object compare with the height and width of the image?

Reflection is the bouncing off of light rays when it hits a surface like a plane mirror. In the activity, you used plane mirrors and located the object distance, **p** and the image distance, **q** and found out that p is equal to q. In plane mirrors, the image appears as if it is behind the mirror but actually not, so the image is virtual. The value therefore of image distance, q is negative. The height of the image, **h'** in plane mirrors is always the same as the height of the object, thus its magnification, **M** is 1. The magnification formula is written below:

$$M = \frac{h'}{h} = \frac{-q}{p}$$

To learn more about reflection of light in plane mirrors, try the next activity. However, here are some important terms which you need to understand first.

Incident Ray. The ray of light approaching the mirror represented by an arrow approaching an optical element like mirrors.

Reflected Ray. The ray of light which leaves the mirror and is represented by an arrow pointing away from the mirror.

Normal Line. An imaginary line (labeled N in Figure 3) that can be drawn perpendicular to the surface of the mirror at the point of incidence where the ray strikes the mirror.

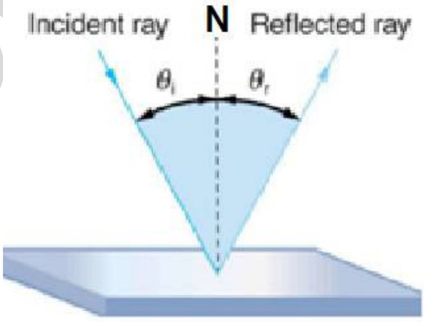


Figure 3. Reflection of a Light Ray on a Plane Mirror

The angle between the incident ray and the normal line is known as the angle of incidence, Θ_i. The angle between the reflected ray and the normal is known as the angle of reflection, Θ_r.

Activity 2

Angle of Incidence vs. Angle of Reflection

Objectives:

- Compare the angle of reflection and the angle of incidence.
- State one of the laws of reflection.

Materials:

- 1 plane mirror
- 1 low – frequency laser/ laser pen/laser pointer
- 1 paper protractor (see Appendix A)

Procedure:

1. Let the mirror stand vertically along the edge of the paper protractor as shown in Figure 4. Use the clay to support the plane mirror.

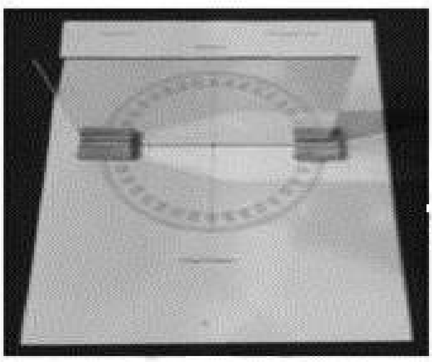


Figure 4. A Plane mirror on a paper protractor

2. Position the laser beam such that it hits the mirror at an angle of 10^o with the normal line. Measure the angle between the reflected ray and the normal line. Record your measurement in a table similar to Table 3.
3. Make three trials and get the average.
4. Repeat steps 2 to 4 for angles 20^o, 30^o, 40^o, and 50^o. Enter all your measurements in Table 3.

Table 3. Angles of Incidence and Reflection

Angle of Incidence	Angle of Reflection			
	Trial 1	Trial 2	Trial 3	Ave.
10^o				
20^o				
30^o				
40^o				
50^o				

Q3. How does the angle of incidence compare with the angle of reflection?

Q4. A periscope is an instrument for observation over, around or through an obstacle. Explain how light travels in a periscope. Diagram the light rays as these pass through the periscope.

In the activity, you found out that the angle of incidence (Θ_i) is equal to the angle of reflection (Θ_r).

In symbols:

$$\Theta_i = \Theta_r$$

This is one of the laws of reflection. The other law states that:

"The normal line, incident ray, and the reflected ray lie on the same plane."

Reflection of light is employed significantly in making optical instruments like periscopes. Periscopes allow sea navigators in a submarine to see the surface of the water.

Try the next activity to further investigate the reflection of light in plane mirrors

Activity 3

Mirror Left-Right Reversal

Objectives:
- Describe the images formed by plane mirror.
- Show an understanding of reversal effect in mirrors by writing laterally inverted letters and words.

Materials:
- alphabet chart
- 1 plane mirror

Procedure:
1. Place the alphabet chart in front of the plane mirror. Identify all capital letters in the alphabet that can be read properly in front of the mirror.
2. Write at least 3 words (all in capital letters) that can be read properly both with a mirror and without a mirror in front of it.

Q5. What are the letters of the alphabet (in capital) that can be read properly in front of a mirror?

Q6. Think of words (in capital letters) that can be read properly both with a mirror and without a mirror. What are these words?

Q7. Write the sentence below on a clear sheet of paper in such a way that it can be read properly in front of a mirror:

Honesty is the best policy.

Mirror Left-Right Reversal

Figure 5 shows a girl combing her hair with her left hand. However, in her image, you will notice that she is combing her hair with her right hand. This effect is known as the mirror left-right reversal. The left side of the object appears as the right side of the image and the right side appears as the left. This also explains why the word "AMBULANCE" in an ambulance car is flipped.

Figure 5. Mirror Left-Right Reversal

Do the next activity to learn more about reflection of light, this time using two plane mirrors. You will explore how the angle between two plane mirrors affects the number of images formed.

Activity 4

Who wants to be a Millionaire?

Objectives:

- Identify the relationship between the number of images formed and the angle between the two mirrors.
- Use the gathered data to derive the formula for determining the number of images formed when two mirrors are kept at a certain angle.

Materials:

- 1 one-peso coin
- 1 paper protractor
- 2 plane mirrors

Procedure:

1. Place two plane mirrors at an angle of 90° and place the one-peso coin between the mirrors as shown in Figure 6.

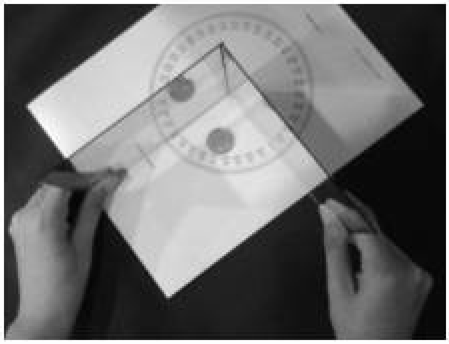


Figure 6. Two plane mirrors at 90 degree angle

2. Count the number of images formed. Record this in a table similar to Table 4 below.
3. Try to vary the angle between the mirrors.

   Q8. What happens to the number of images formed as you vary the angle between the mirrors?

4. Set the angle between the mirrors to 60°. Count and record again the number of images formed.
5. Do again step 4 for angles 45° and 30°. Enter all the values in a table similar to Table 4

Table 4. Number of Images Formed

Angle	Number of Images
90°	
60°	
45°	
30°	

Q9. Refer to Table 4. What relationship exists between the number of images formed and the angle between two mirrors?

Q10. Use the data in Table 4 to derive the formula for determining the number of images formed by two mirrors?

Q11. How should the mirrors be arranged such that an infinite number of images will be formed or seen?

Multiple Images

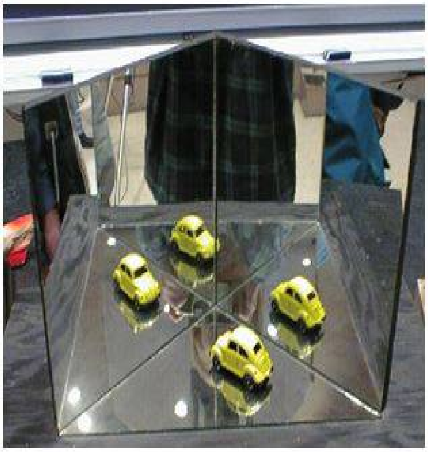


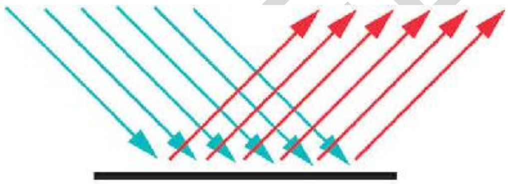
Figure 7. Multiple Images Formed by Two Plane Mirrors at 90°Angle

Have you seen a lot of money in your previous activity? Multiple images are formed by the reflection that happens when arranging at least two mirrors. Figure 7 shows three images of a toy car in front of two mirrors at 90°. The number of images, N, can be determined using the formula N = (360/angle between the mirror) -1. Parallel mirrors on the other hand produce infinite number of images.

Reflection not only happens on a smooth surface like plane mirrors, but also happens on rough surfaces. This is why reflection is classified into two types.

Types of Reflection:

1. Specular/ Regular Reflection. This is a reflection of light on smooth surfaces such as mirrors or a calm body of water. An example of this is the image of the Mayon volcano on a calm water shown in Figure 8b.

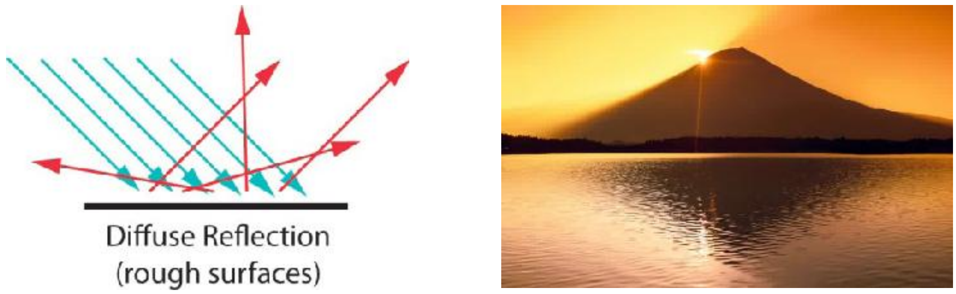


(a) (b)

Sources: http://www.orcagrowfilm.com/Articles.asp?ID=148 & http://www.wallpaperup.com/225284/landscape_nature_trees_mountain_Mount_Mayon_Philippines_Luzon_reflection_volcano_g.html

Figure 8. Specular Reflection. (a) Parallel light rays reflect in one direction (b) Mayon Volcano and its reflection on calm water

2. Diffused/Irregular Reflection. This is a reflection of light on rough surfaces such as clothing, paper, wavy water, and the asphalt roadway. An example of this is the image of a mountain on a wavy body of water as shown in Figure 9b.



(a) (b)

Sources: http://www.orcagrowfilm.com/Articles.asp?ID=148 & http://www.wallpaperup.com/29790/sunset_mountains_reflection.html

Figure 9. Diffused Reflection. (a) Parallel light rays reflect in different directions. (b) A mountain and its reflection on wavy water

The following lesson presents a specular/ regular reflection (because it happens on a smooth surface) but the reflected rays do not follow one direction. Why is that so? Let us find out.

Reflection on Spherical Mirrors

Look at your reflection on a shiny metal spoon. Is your reflection the same on the two surfaces of the spoon? How will you compare your reflection on the two surfaces of the spoon? This is a reflection on curved mirrors.

A curved mirror is a reflecting surface in which its surface is a section of sphere. There are two kinds of curved mirrors, the concave and the convex mirrors. A spoon is a kind of a curved mirror with both concave and convex surfaces.

<u>Two Kinds of Spherical Mirrors:</u>

1. The Concave Mirror
   - It is a curved mirror in which the reflective surface bulges away from the light source.
   - It is called Converging Mirror because the parallel incident rays converge or meet/intersect at a focal point after reflection.

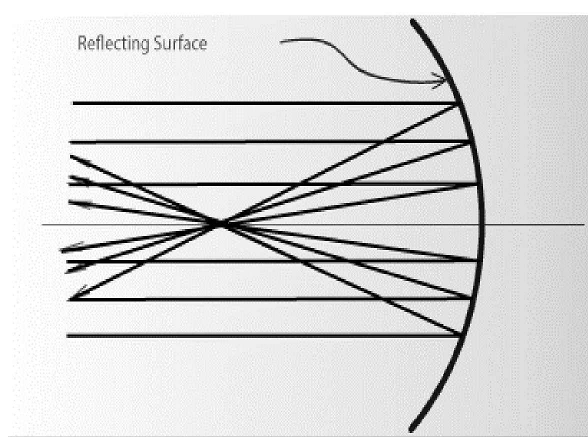


Figure 10. Parallel rays converge after reflection on a concave mirror

2. The Convex Mirror

- It is a curved mirror in which the reflective surface bulges towards the light source.
- It is called Diverging Mirror because the parallel incident rays diverge after reflection. When extending the reflected rays behind the mirror, the rays converge at the focus behind the mirror.

Figure 11. Parallel light rays diverge after reflection on a convex mirror

To know more about curved mirrors and how images are formed when objects are placed in front of them, try Activity 5 below.

Activity 5

Images Formed by Curved Mirrors

Objective:

Describe the location, size, and orientation of the images formed by curved mirrors.

Materials:

- Improvised optical bench apparatus
- Curved mirror (concave and convex)
- Mirror stand
- Screen or white cardboard
- Flashlight
- Meter stick
- Sheet of paper (colored black)

Procedure:

1. Cut a U-shaped object from a cartolina with a size that fits the glass cover of the flashlight. Attach the U-shaped object to the cover of the flashlight. Refer to Figure 12.

Figure 12. A U-shaped object attached to the flashlight

2. Position the concave mirror intact with the mirror stand at the center of two meter sticks as shown in Figure 13 below.

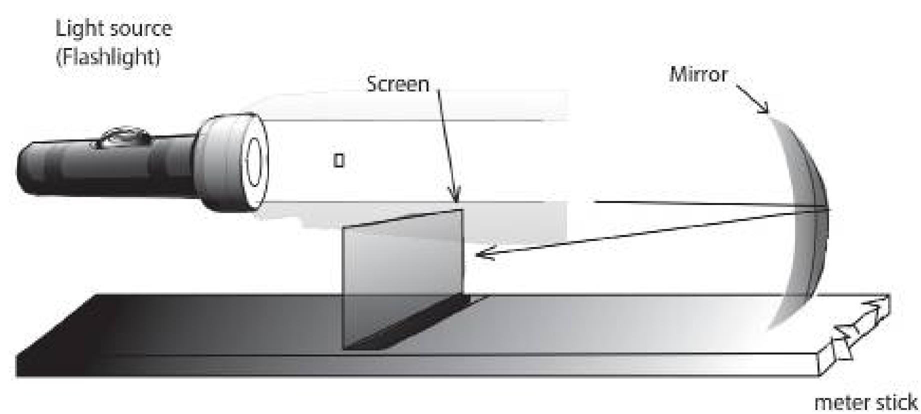


Figure 13. Set-up for Curved Mirror Experiment

3. Mark the improvised optical bench or meter sticks at the following points: the focal point F (see the specified focal length on label of the mirror), and the center of curvature, C which is equal to 2F.
4. Place the flashlight at a distance farther than the center of curvature, C in front of the mirror.
5. Allow the light rays coming from the flashlight to strike the mirror.
6. Place a screen (a white cardboard) at a distance in front of the mirror. Move the screen in different distances in front of the mirror until a clear and sharp image of the U-shape is formed on the screen. Note the size and location of the image formed (on the screen).
7. Do the same thing in different location of the object by moving the flashlight at the center of curvature C, near the focal point, F at the focal point, and between the focal point and the mirror.

Q12. What happens to the size and location of the image when you bring the flashlight nearer to the concave mirror?

8. Repeat steps 3, 5, and 7 using a convex mirror. This time, you will not use the screen. Look through the convex mirror to see the image.

Q13. What is the generalization from the nature of images formed by convex mirror and concave mirror?

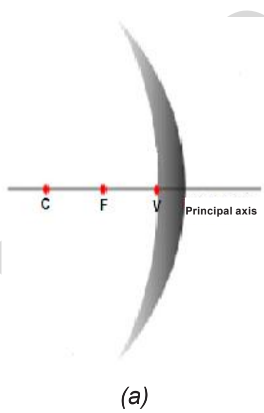
This activity is adapted from Lesson Plans in Science IV, Unit II Energy in the Environment, Activity 2.5 Images Formed by Curved Mirrors.

In Activity 5 using a concave mirror, you observed that images formed on the screen are inverted. Images formed on a screen, after reflection, are called real images because they are formed by the intersection of real reflected rays.

A virtual image, on the other hand, does not form on a screen because a virtual image is formed by the intersection of non-real rays.

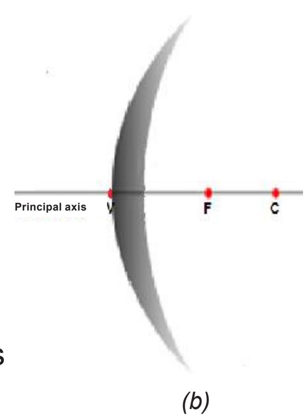
Images Formed by Curved Mirrors

In locating the image formed in curved mirror graphically, three important points are considered. The following important points are enumerated below.



(a)

- Center of Curvature, **C** - the center of the sphere of which the mirror is part. Its distance from the mirror is known as the radius.
- Vertex, **V** - the center of the mirror.
- Focal Point/ Focus, **F** - the point between the center of the curvature and vertex. Its distance from the mirror is known as the focal length, **f**.



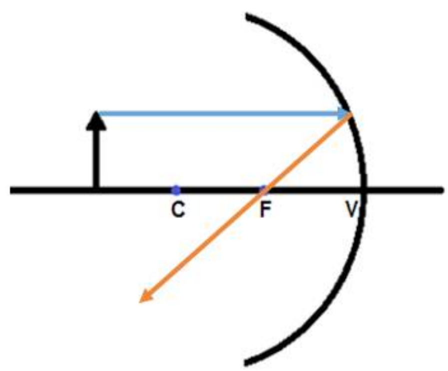
(b)

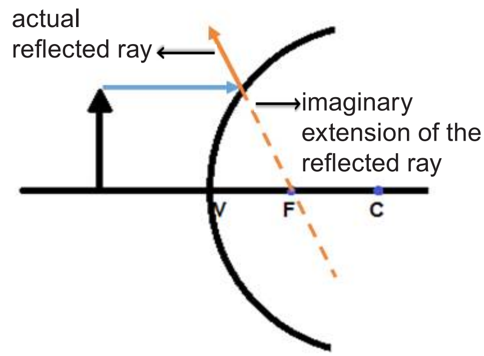
Figure 14. Curved Mirrors (a) Concave Mirror (b) Convex Mirror

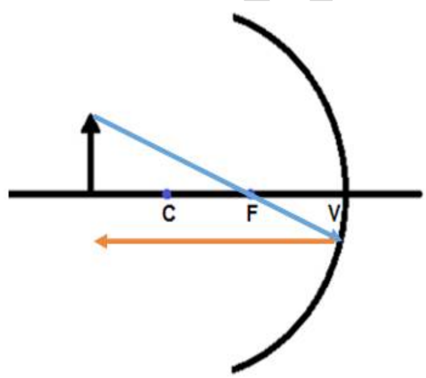
The 'Four Principal Rays' in Curved Mirrors

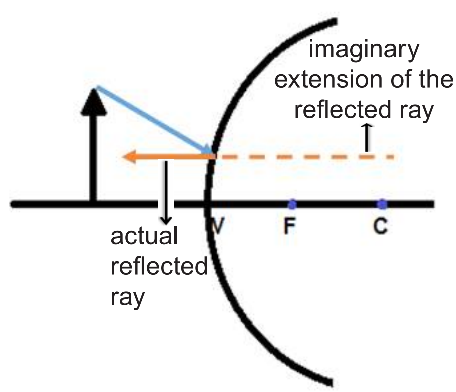
Images formed in a curved mirror can be located and described through ray diagramming. The P – F ray, F – P ray, C – C ray, and the V ray are the 'Four Principal Rays' in curve mirrors. These rays, applied for concave and convex mirrors, are presented in Table 5.

Table 5. The 'Four Principal Rays' on Concave and Convex Mirrors

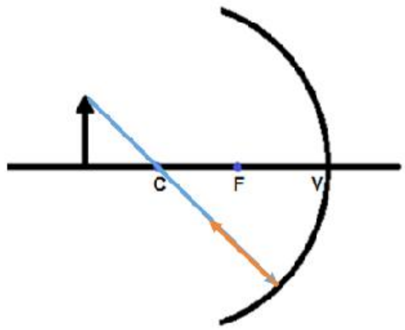
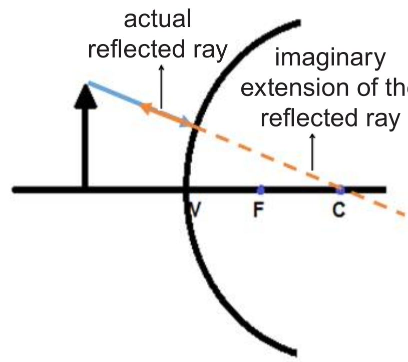
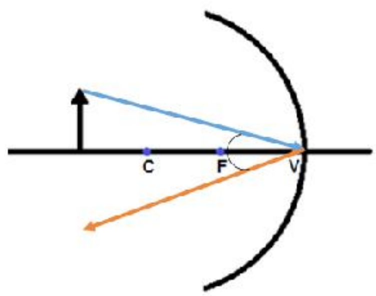
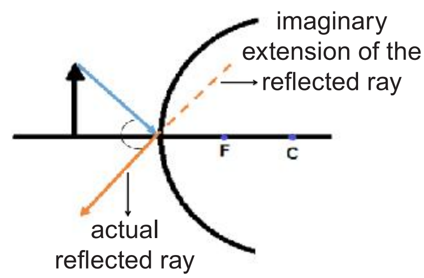
<table>
<tr><th>Concave Mirror (Converging Mirror)</th><th>Convex Mirror (Diverging Mirror)</th></tr>
<tr><td>


1. <u>P – F Ray</u>. A ray of light parallel to the principal axis is reflected passing through the principal focus, F.
</td><td>


1. <u>P – F Ray</u>. A ray of light parallel to the principal axis is reflected as if passing through the principal focus, F.
</td></tr>
<tr><td>


2. <u>F – P Ray.</u> A ray of light passing through the focus, F is reflected parallel to the principal axis.
</td><td>


2. <u>F – P Ray</u>. A ray of light directed towards the focus, F is reflected parallel to the principal axis.
</td></tr>
</table>

 3. C – C Ray. A ray of light passing through the center of curvature, C reflects back along its own path.	 3. C – C Ray. A ray of light directed towards the center of curvature, C reflects back along its own path.
 4. V Ray. A ray of light directed to the vertex reflects at equal angle from the principal axis	 4. V Ray. A ray of light directed to the vertex reflects at equal angle from the principal axis.

In determining the position and nature of the image graphically, the 'Four Principal Rays' are used. Ray diagramming is used in the graphical method of locating the image. The following are ray diagramming steps using the 'Four Principal Rays' in determining the position and the nature of the image of an object formed by concave mirror and convex mirror.

1. From the object, draw the first ray (P – F ray). From the same point on the object, draw the second (F – P ray), third (C – C ray), and fourth (V ray) rays.
2. The intersection of the four rays is the image point corresponding to the object point. For example, if you started diagramming from the tip of the arrow-shaped object, the intersection of the reflected rays is also the tip of the arrow-shaped image. Thus, you can determine completely the position and characteristics of the image.

3. For a convex mirror, light rays diverge after reflection and converge from a point that seems to be behind the mirror (virtual focus); but the procedure for locating images is the same as for concave mirror.

In the next activity, you will use the steps described above to locate and describe the images formed by concave and convex mirrors through graphical method. To do this, always start by drawing the curved mirror and its principal axis, then identify the F and C on the principal axis. Next is to draw the object then diagram the rays from the object.

Activity 6

Are you L-O-S-T after Reflection?

Objective:

Construct ray diagrams to determine the location, orientation, size, and type of images formed by curved mirror.

Materials:

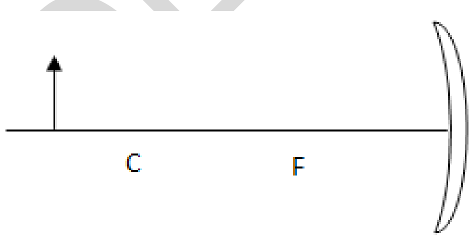
- Protractor and ruler
- Sheets of paper

Procedure:

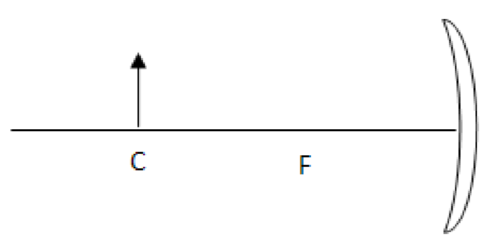
1. Using the protractor and the ruler, copy each of the diagrams (A – G) below on a separate sheet of paper. As much as possible, use the four principal rays to locate the image formed in a curved mirror.

Concave Mirror

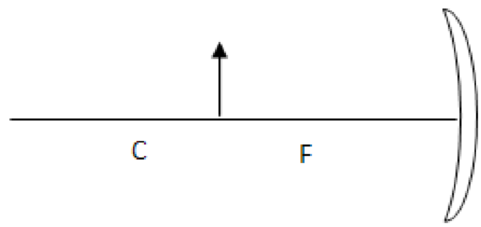
A.



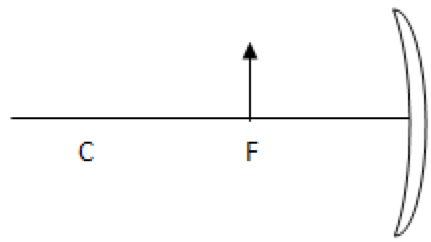
B.



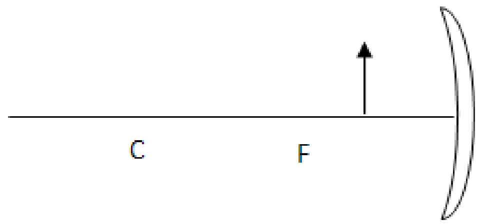
C.



D.

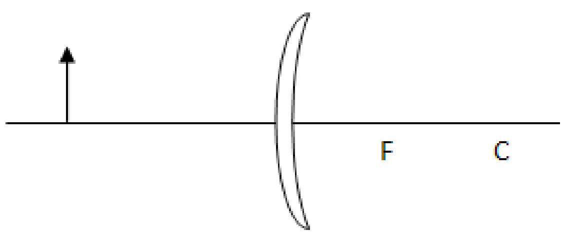


E.

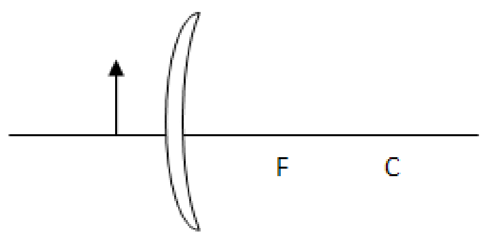


Convex Mirror

F.



G.



2. Use a table similar to Table 6 below to summarize the characteristics and location of the images formed.

Table 6. Location, Orientation, Size, and Type of Image Formed in Curved Mirrors

Location of Object	Image			
	Location	Orientation (upright or inverted)	Size (same, reduced or enlarged)	Type (real or virtual)
CONCAVE A. Farther than the Center of Curvature				
B. At the Center of Curvature				
C. Between the Center of Curvature and the Focal point				
D. At the Focal point				
E. Between the Focal point and the Center of the lens (Vertex)				
CONVEX F. Farther than C in front of the Mirror				
G. Between F and V in front of the Mirror				

Q14. Refer to Table 6. How does the location of the object affect the characteristics and location of the image formed in a concave mirror? Convex mirror?

____

____

Q15. What type of mirror do dentists usually use to clearly see the images of our teeth? Why?

____

____

Q16. What kind of curved mirror do you see in most of the department stores? Why do they use such kind of mirror?

____

____

This activity, which you have just performed is more detailed on the location, orientation, size, and type of the images formed. Did this activity in curved mirrors confirm your observations in the previous activity (Activity 5)?

The Mirror Equation

Ray diagrams provide useful information about the image formed, yet fail to provide the information in a quantitative form. Ray diagrams will help you determine the approximate location and size of the image, but it will not provide you with the numerical information about image distance and object size. To determine the exact location and size of the image formed in a curved mirror, an equation is needed. The following derivation shows the mirror equation using the Figure 15 below.

From the first and fourth rays, similar triangles are seen in the figure below.

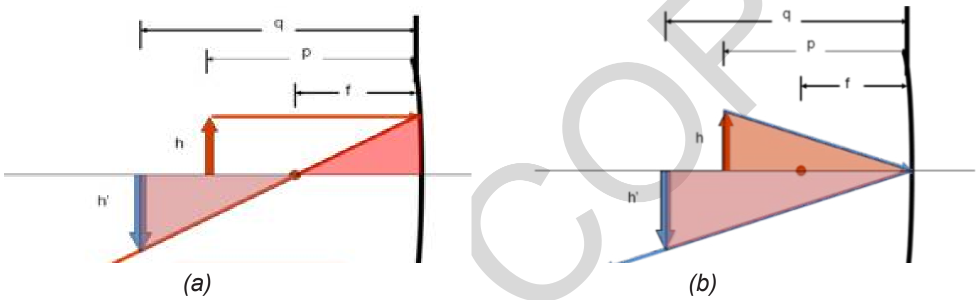


Figure 15. Similar Triangles Formed using the (a) first ray (P – F ray) and (b) fourth ray (V ray).

From the height of the object, h and the height of the image, h' shown in Fig. 15 (a), you can arrive at the first equation,

$$\frac{h'}{h} = \frac{q-f}{f} \qquad \textit{Equation 1}$$

Similarly, as shown in Fig. 15 (b), the second equation can be derived as

$$\frac{h'}{h} = \frac{q}{p} \qquad \textit{Equation 2}$$

Combining Equations 1 and 2, you will get

$$\frac{q-f}{f} = \frac{q}{p} \qquad \textit{Equation 3}$$

Rearranging Equation 3, you will arrive at

$$\frac{q}{f} - 1 = \frac{q}{p}$$

$$\frac{q}{f} = \frac{q}{p} + 1$$

$$\frac{1}{f} = \frac{q}{pq} + \frac{1}{q}$$

and finally,

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$ *Mirror Equation*

where: f = focal length or distance from the mirror and the focal point, F
p = distance of the object from the mirror
q = distance of the image from the mirror

The equation above, called **mirror equation**, applies to both concave and convex mirrors. However, for all location of objects in front of the convex mirror, the image always appears as if it is located behind the mirror. It is therefore considered that the value of image distance, q is negative. In the same manner, the focus, F in a convex mirror is located on the other side of the mirror (behind the mirror), thus, the focal length, f is also negative.

Sample Problem:

A 5.00-cm tall light bulb is placed at a distance of 45.0 cm from a concave mirror having a focal length of 10.5 cm. Determine the image distance and the image size.

Given:
height of the object, h = 5.00 cm
distance of the object, p = 45.0 cm
focal point, f = 10.5 cm

Find:
distance of the image, q = ?
height of the image, h' = ?

The mirror equation must be used to determine the distance of the image, q.

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

$$\frac{1}{10.5cm} = \frac{1}{45.0\ cm} + \frac{1}{q}$$

$$\frac{1}{10.5cm} - \frac{1}{45.0\ cm} = \frac{1}{q}$$

$$\frac{45.0\ cm - 10.5\ cm}{(10.5\ cm)(45.0\ cm)} = \frac{1}{q}$$

$$\boldsymbol{q = 13.7\ cm}$$

To determine the image height, the magnification equation is needed. Since three of the four quantities in the equation are known, the fourth quantity can be calculated.

$$\frac{h'}{h} = \frac{-q}{p}$$

$$\frac{h'}{5.00\ cm} = \frac{-\ 13.7\ cm}{45.0\ cm}$$

$$h' = \frac{(5.00\ cm)(-13.7\ cm)}{45.0\ cm}$$

$$\boldsymbol{h' = -1.52\ cm}$$

The negative value for image height indicates that the image is an inverted image.

Try solving this…

1. What is the image distance and image height if a 7.00-cm tall object is placed 30.0 cm from a concave mirror having a focal length of 10.0 cm?
2. A magnified, inverted image is located a distance of 30.0 cm from a concave mirror with a focal length of 15.0 cm. What is the object distance?

Sample Problem:

What is the focal length of a convex mirror that produces an image that appears 15.0 cm behind the mirror when the object is 27.5 cm from the mirror?

Given:

q = -15.0 cm

p = 27.5 cm

Find:

f = ?

To determine the focal length, f, the mirror equation will be used. Substitute and solve for f.

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

$$\frac{1}{f} = \frac{1}{27.5\ cm} + \frac{1}{-15.0\ cm}$$

$$\frac{1}{f} = \frac{-15.0\ cm + 27.5\ cm}{(27.5\ cm)(-15.0\ cm)}$$

$$\boldsymbol{f = -33.0\ cm}$$

The negative value for focal length confirms that the mirror used is a convex mirror.

Try solving this…

3. An object is placed 33.7 cm from the convex mirror with a focal length of 10.7 cm. Determine the image distance.
4. A 7.0-cm tall light bulb is placed a distance of 37.5 cm from a convex mirror having a focal length of -12.5 cm. Determine the image distance and the image size.

The Sign Conventions for Mirror

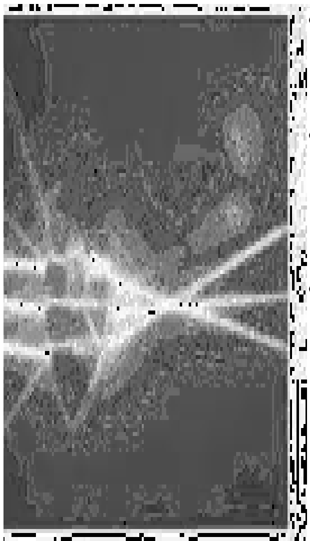
- f is positive (+) if the mirror is a concave mirror
- f is negative (-) if the mirror is a convex mirror
- q is (+) if the image is a real image and located on the object's side of the mirror.
- q is (-) if the image is a virtual image and located behind the mirror
- h' is (+) if the image is an upright image
- h' is (-) if the image an inverted image

Refraction of Light in Lenses

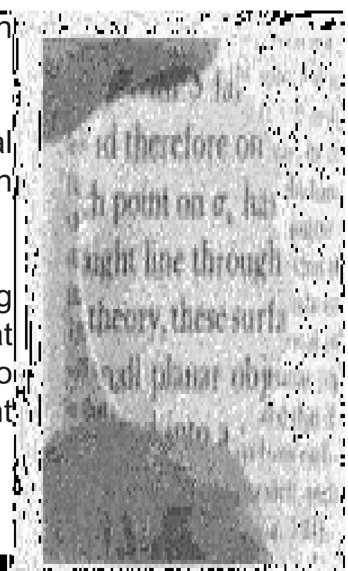
You learned in Grade 8 that Refraction is the bending of light when it travels from one medium to another of different optical densities. The ancient Greeks used the concept of light refraction in their living like using a lens to focus light rays. A lens is a transparent material made of glass or plastic that refracts light rays and focuses (or appear to focus) them at a point.

Types of Lenses

1. Convex Lens



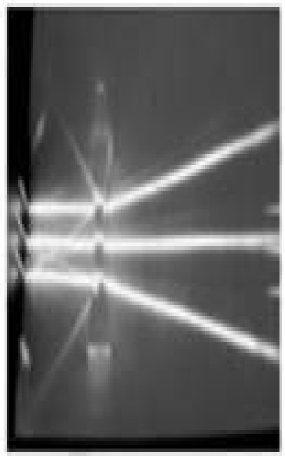
- It is thicker in the center than edges.
- It forms real images and virtual images depending on position of the object.
- It is also called Converging Lens because the light that passes through it tends to converge at a particular point called the focal point.



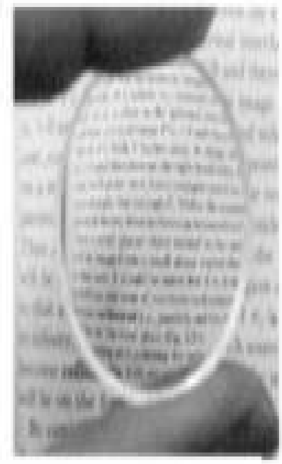
(a) (b)

Figure 16. Convex Lens. (a) Parallel light rays converge after refraction. (b) A converging lens magnifying the words from a book

2. Concave Lens



- It is thicker at the edges and thinner in the center.
- It forms upright and reduced images.
- It is also called Diverging Lens because the light that passes through it tends to diverge at a particular point called the focal point.



(a) (b)

Figure 17. Concave Lens. (a) Parallel light rays diverge after refraction. (b) A diverging lens demagnifying the words from a book.

Activity 7

YoU can be Magnified!

Objectives:

- Measure the focal length and linear magnification of a convex lens.
- Locate the image formed by convex lens.
- Describe the image formed by a convex lens.

Materials:

- convex lens or magnifying glass
- lens holder e.g. clay
- meterstick
- index card

Procedure:

1. Hold the convex lens under a ceiling light. A projection screen (e.g. the floor or the surface table) should be placed under the convex lens.
2. Move the convex lens up and down until a sharp image of the ceiling light is projected on the screen.
3. Measure the distance between the lens and the projection surface using a ruler.

Q17. What is the focal length of the convex lens?

Q18. How would you describe the image formed if a distant object is used?

4. Mount the convex lens on a clay. Draw a U–shaped object on an index card and mount the index card on another clay. Initially place the index card beside the zero (0) mark on the meter stick, and place the lens in front of the index card as shown in Figure 18a below:

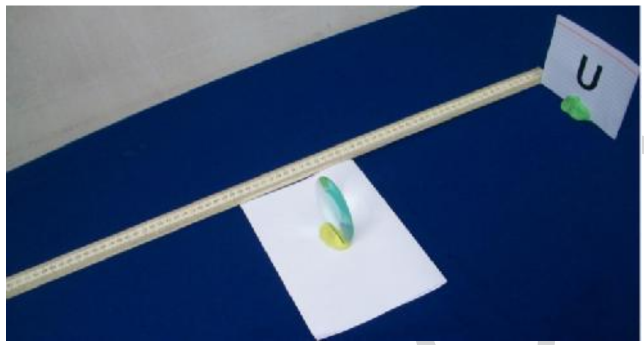


Figure 18a. Set-up for Lens Experiment

5. Look through the lens and move the lens until you can clearly see an enlarged and upright image of the U-shaped object as shown in Fig. 18b below.

Figure 18 b. Looking at the U-shaped Object through the Lens

6. Measure the distance between the convex lens and the card using a meter stick. Record your observation on the second column of a table similar to Table 7.
7. Measure the distance between the lens and your eye. Record your observation on the third column of a table similar to Table 7.
8. Move again the convex lens back and forth, until you can clearly see, this time, an enlarged and inverted image of the U-shaped object. Then, repeat steps 6 and 7.
9. Move again the convex lens so that you can clearly see a reduced and upside down image of the U-shaped object. Repeat steps 6 and 7.

Table 7. Distances from the Lens of Object and your Eye

Description of Image	Distance between the Object and the lens (cm)	Distance between the Eye and the lens(cm)
Enlarged and upright		
Enlarged and inverted		
Reduced and inverted		

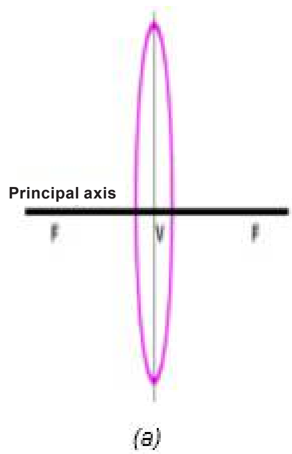
Q19. What kind of lenses are magnifying glasses? When a magnifying glass produces a sharp clear image, where is the object located in relation to the lens?

Q20. Where should a magnifying glass be placed to produce an e larged and upright image, closer to the eye or nearer to the object? Why?

From the activity, you were able to determine the focal length of a lens. You were also able to measure the distance of the object and the image from the lens. These quantities are very significant in describing the image formed. Images formed by lenses can also be real or virtual. In Activity 7, using a convex lens, you observed that images are formed on the screen. Images formed on a screen, after refraction, are called real images because they are formed by the intersection of real refracted rays. A virtual image, on the other hand, does not form on a screen because a virtual image is formed by the intersection of non-real rays.

Images Formed by Lenses

In locating the image formed in lenses graphically, two important points are considered. The following important points are enumerated below.



- Vertex, V – The geometric center of the lens.
- Focal point/ Focus, F – A point where light rays converge (or appears to converge) when parallel light rays pass through a lens. Its distance from the vertex is called the focal length.

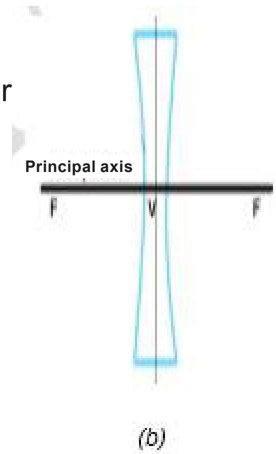
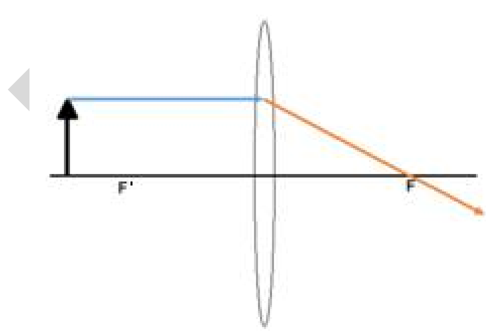
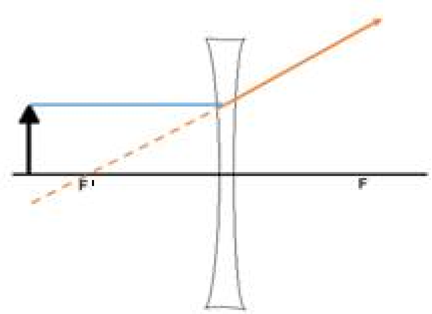


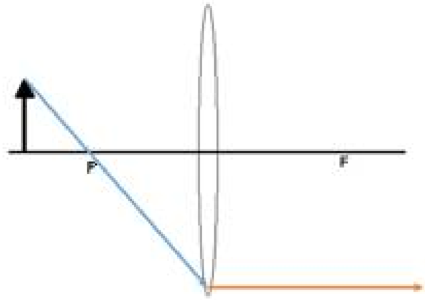
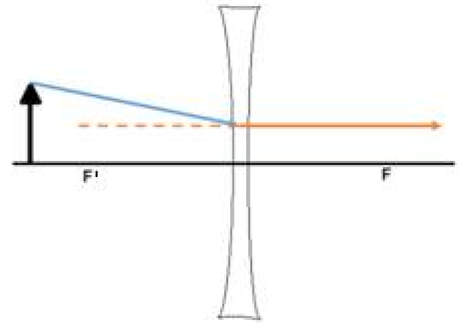
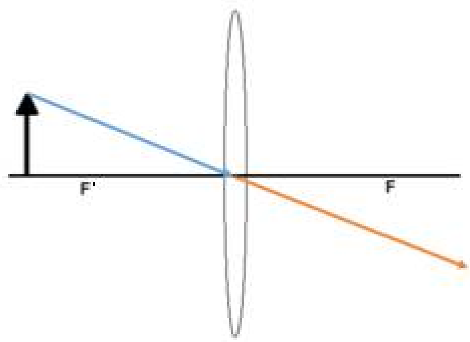
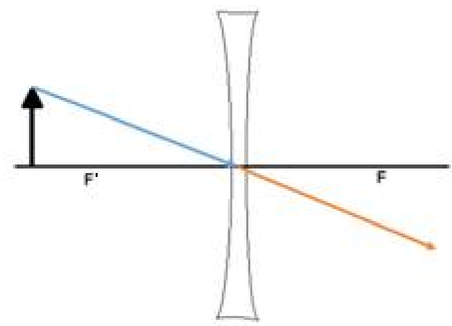
Figure 19. Lenses (a) Convex Lens (b) Concave Lens

The 'Three Most Useful Rays' in Lenses

Images formed in a lens can be located and described through ray diagramming. The following three most useful rays for convex and concave lenses are presented below.

Table 8. The Three 'Most Useful Rays' in Convex and Concave Lenses

Convex Lens (Converging Lens)	Concave Lens (Diverging Lens)
 1. <u>P–F Ray</u>. A ray of light parallel to the principal axis is refracted passing through the principal focus, F behind the lens.	 1. <u>P–F Ray</u>. A ray of light parallel to the principal axis is refracted as if passing through the principal focus, F in front of the lens.

 2. F–P Ray. A ray of light passing through the focus, F in front of the lens is refracted parallel to the principal axis.	 2. F–P Ray. A ray of light directed towards the focus, F behind the lens is refracted parallel to the principal axis.
 3. V Ray. A ray of light passing through the exact center of the lens (Vertex) continue to travel in the same direction.	 3. V Ray. A ray of light passing through the exact center of the lens (Vertex) continue to travel in the same direction.

To graphically determine the position and kind of the image formed, the ray diagram can be used. Consider the following steps using the three major rays described above:

1. From the object, draw the first ray (P–F ray). From the same point on the object, draw the second (F–P ray), and third (V ray) rays.

2. The intersection of the rays is the image point corresponding to the object point. For example, if you started diagramming from the tip of the arrow-shaped object, the intersection of the refracted rays is also the tip of the arrow-shaped image. Thus, you can determine completely the position and characteristics of the image.

3. For a concave lens, light rays diverge from a virtual focus; but the procedure for locating images is the same as for convex lenses.

In the next activity, you will use the steps described above to locate and describe the images formed by convex and concave lenses by graphical method. To do this, always start by drawing the lens and its principal axis, then identify the F and 2F on the principal axis. Next is to draw the object, then diagram the rays from the object.

Activity 8

Are you L-O-S-T after Refraction?

Objectives:

- Construct ray diagrams for lenses.
- Determine graphically the location, orientation, size, and type of image formed.
- Show graphically the changes in the image formed as an object's position is changed.

Materials:

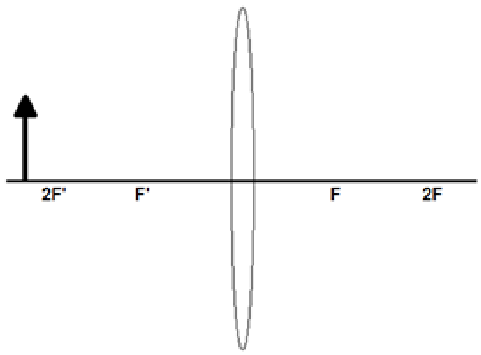
- paper
- ruler

Procedure:

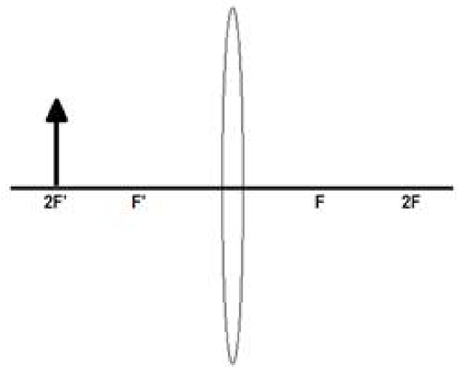
1. Copy each of the diagrams (A–H) below on a clear sheet of paper. Construct ray diagram using, as much as possible, the 'three most useful rays' for each of the following cases to determine the location, orientation, size, and type of the image.

Convex Lens

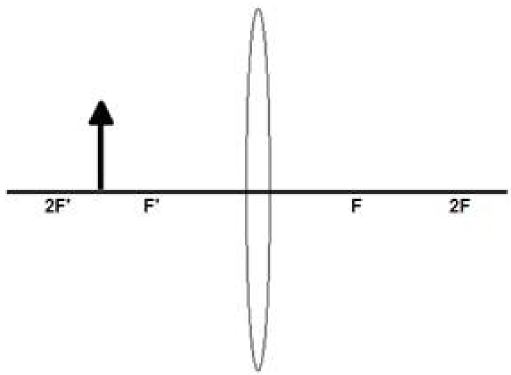
A.



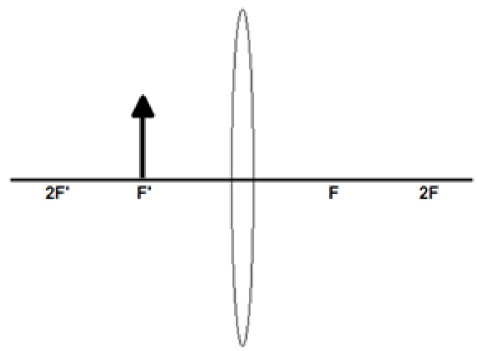
B.



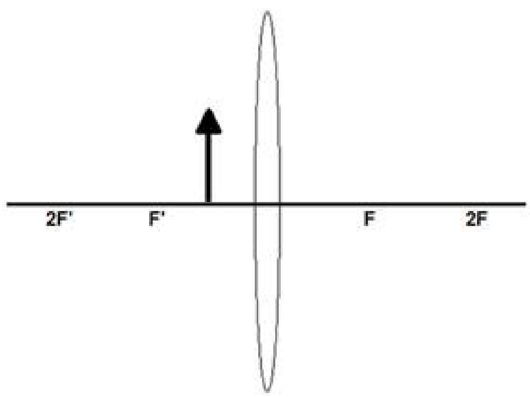
C.



D.

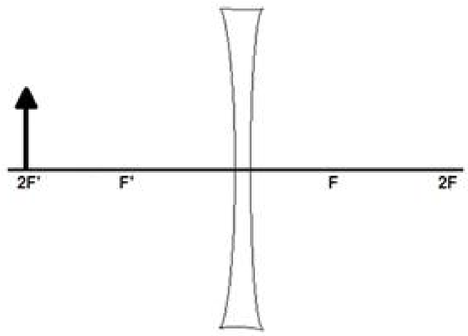


E.

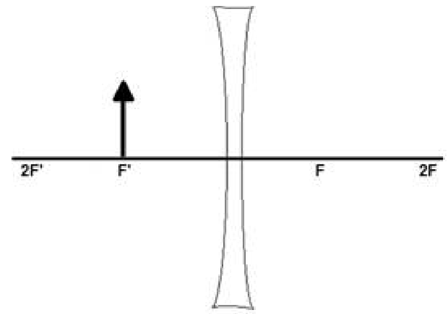


Concave Lens

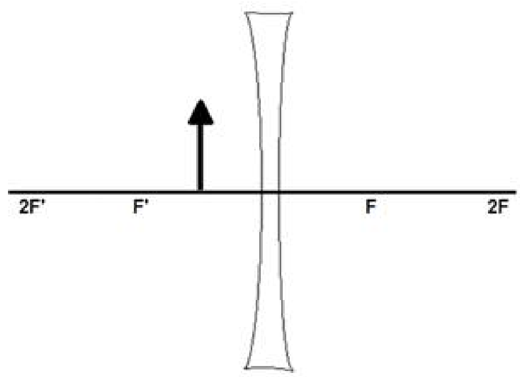
F.



G.



H.



2. Use a table similar to Table 9 below to summarize the characteristics and location of the images formed.

Table 9. Location, Orientation, Size, and Type of Image Formed by Lenses

Location of Object	Image			
	Location	**O**rientation (upright or inverted)	**S**ize (same, reduced or enlarged)	**T**ype (real or virtual)
CONVEX LENS A. Beyond 2F'				
B. At 2F'				
C. Between 2F' and F'				
D. At the Focal point, F'				
E. Between F' and V				
CONCAVE LENS F. At 2F'				
G. At the Focal point, F'				
H. Between F' and V				

Q21. Refer to Table 9. How does the image change in its size and location, as the object comes nearer the convex lens? Concave lens?

Q22. Refer to the size of object and the size of image from the drawn ray diagrams for convex lens. Identify the location of object for which the following optical instruments are used to. Match column A with column B.

Column A	**Column B**
photocopy "Xerox" Machine	At Infinity
Camera	Beyond 2F'
Telescope	At 2F'
Projector	Between 2F' and F'
Magnifying Glass	Between F' and V

Q23. Why is it impossible for a concave lens to form a real image?

The Lens Equation

Ray diagram does not provide exact location and numerical information about the image formed in lenses, as in the image formed in curved mirrors through ray diagram. To determine the exact location and size of the image formed in lenses, a lens equation is needed. The following derivation shows the lens equation using the results from ray diagram.

From the first and third rays, similar triangles are seen in the diagram.

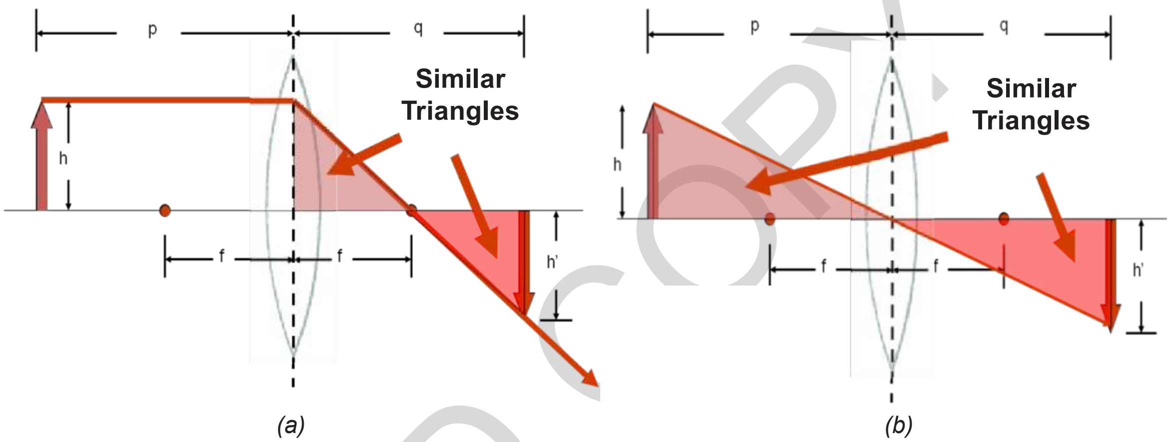


Figure 20. Similar Triangles are Formed using the (a) first ray (P – F ray) and (b)third ray (V ray).

From the height of the object, h and the height of the image, h' shown in Figure 20 (a), you can arrive at the first equation,

$$\frac{h'}{h} = \frac{q - f}{f} \qquad \textit{Equation 1}$$

Similarly, as shown in Figure 20(b), the second equation can be derived as

$$\frac{h'}{h} = \frac{q}{p} \qquad \textit{Equation 2}$$

Combining Equations 1 and 2, you will get

$$\frac{q - f}{f} = \frac{q}{p} \qquad \textit{Equation 3}$$

Rearranging Equation 3, you will arrive at

$$\frac{q}{f} - 1 = \frac{q}{p}$$

$$\frac{q}{f} = \frac{q}{p} + 1$$

$$\frac{1}{f} = \frac{q}{pq} + \frac{1}{q}$$

and finally,

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

Lens Equation

where: f = focal length or distance from the mirror and the focal point,F
p = distance of the object from the lens
q = distance of the image from the lens

The equation above, called mirror equation, applies to both convex and concave lenses. However, in the case of the concave lens, the image will always be located on the side where the object is also located. It is therefore considered that the value of image distance, q is negative. The focal length, f in a concave lens is negative while positive in a convex lens.

<u>Sample Problem:</u>

What is the image distance and image size if a 5.00-cm tall light bulb is placed a distance of 45.5 cm from a convex lens having a focal length of 15.4 cm?

Given:

h = 5.00 cm

p = 45.5 cm

f = 15.4 c

Find:

d = ?

q = ?

To determine the image distance, the lens equation must be used.

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

$$\frac{1}{15.4\ cm} = \frac{1}{45.5\ cm} + \frac{1}{q}$$

$$\frac{1}{15.4\ cm} - \frac{1}{45.5\ cm} = \frac{1}{q}$$

$$\frac{45.5\ cm - 15.4\ cm}{(15.4\ cm)(45.5\ cm)} = \frac{1}{q}$$

$$\boldsymbol{q = 23.3\ cm}$$

Since three of the four quantities in the magnification equation are known, the height of the image, h can be calculated.

$$\frac{h'}{h} = \frac{-q}{p}$$

$$\frac{h'}{5.00\ cm} = \frac{-\ 23.3\ cm}{45.5\ cm}$$

$$h' = \frac{(5.00\ cm)(-23.3\ cm)}{45.5\ cm}$$

$$\boldsymbol{h' = -2.54\ cm}$$

The negative values for image height indicate that the image is an inverted image.

In the case of a concave lens, you found out that the image always appears in front the lens. It is therefore considered that the value of image distance, q is negative.

Sample Problem:

What is the image distance and image size if a 3.00-cm tall light bulb is placed a distance of 30.5 cm from a diverging lens having a focal length of -10.2 cm?

Given:

h = 3.00 cm
p = 30.5 cm
f = -10.2 cm

Find:
q = ?
h' = ?

To determine the image distance, the lens equation will be used.

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

$$\frac{1}{-10.2cm} = \frac{1}{30.5\ cm} + \frac{1}{q}$$

$$\frac{1}{-10.2cm} - \frac{1}{30.5\ cm} = \frac{1}{q}$$

$$\frac{30.5\ cm + 10.2\ cm}{(-10.2\ cm)(30.5\ cm)} = \frac{1}{q}$$

$$\boldsymbol{q = -7.64\ cm}$$

This confirms the image distance, q as negative. To determine the image height, the magnification equation is needed. Since three of the four quantities in the equation are known, the fourth quantity can be calculated. The solution is shown below.

$$\frac{h'}{h} = \frac{-q}{p}$$

$$\frac{h'}{3.00\ cm} = \frac{-\ 7.64\ cm}{30.5\ cm}$$

$$h' = \frac{(3.00\ cm)(-7.64\ cm)}{30.5\ cm}$$

$$\boldsymbol{h' = -0.75\ cm}$$

Try solving this…

1. Determine the image distance and image height for a 8.00-cm tall object placed 46.5 cm from a convex lens having a focal length of 16.0 cm.
2. A 3.10-cm diameter coin is placed a distance of 25.0 cm from a concave lens that has a focal length of -11.0 cm. Determine the image distance and the diameter of the image.

The Sign Conventions for Lenses

- f is + if the lens is a double convex lens (converging lens)
- f is - if the lens is a double concave lens (diverging lens)
- q is + if the image is a real image and located behind the lens
- q is - if the image is a virtual image and located on the object's side of the lens
- h' is + if the image is an upright image (and therefore, also virtual)
- h' is - if the image an inverted image (and therefore, also real)

So far, you have learned two of the properties of light which are the reflection and refraction. You have gained concepts on the rules of reflection and refraction to describe and explain how the images are formed by mirrors and lenses. You also solved problems pertaining to the exact location and magnification of images formed by mirrors and lenses. In this last activity on Module 2, you will make use of these concepts you learned to improvise an optical device. You will be asked to plan, brainstorm, design, and construct one of the following optical devices.

Activity 9

Making Improvised Optical Device

Option 1: The Camera

Task:

- Construct a pin hole camera and explain the factors that affect the image on the screen

Materials:

- illustration board/cardboard
- black cartolina, cutting mat
- pin/sewing needle, glue/sticky tape
- cutter, scissors, foot ruler, clear lamp

Procedure:

1. With your group mates and using the materials given, design and construct an improvised camera based on the information gathered from different resources.
2. A record sheet is provided to serve as your guide for accomplishing the written report on your constructed camera. Refer to your copy of Attached Assessment Tools: Problem Solving Sheet.

Option 2: The Periscope

Task:

- Construct a periscope and trace the incident and reflected rays.

Materials:

- 2 plane mirrors
- illustration board/cardboard
- cutting mat
- glue/sticky tape
- cutter, scissors, foot ruler, clear lamp

What to do:

1. With your group mates and using the materials given, design and construct an improvised periscope based on the information gathered from different resources.

2. A record sheet is provided to serve as your guide for accomplishing the written report on your constructed periscope. Refer to your copy of Attached Assessment Tools: Problem Solving Sheet.

Option 3: The Microscope

Task:

- Set up a simple microscope and investigate the factors affecting the magnification capabilities of a microscope

Materials:

- set of lenses with different focal lengths
- specimen, light source, ruler or meter stick
- thin, clean sheet of paper to serve as the camera's screen

What to do:

1. Using the materials given, construct or set up a simple microscope. Use knowledge learned in the previous lesson and based on the information gathered from different resources.
2. Discuss with your group mates and agree on one design.
3. Use the problem-solving record sheet as your guide for writing the report on how you were able to construct your microscope.

Option 4: The Telescope

Task:

- Construct a simple telescope and investigate the factors affecting the magnification capabilities of a telescope.

Materials:

- set of lenses with different focal lengths
  specimen, light source, ruler or meter stick
  thin, clean sheet of paper to serve as the camera's screen

What to do:

1. Using the materials listed above, construct a telescope based on information obtained from the previous lesson and other resources. After discussing telescope with your teammates, design a simple telescope.

2. Use the problem-solving record sheet as your guide for writing the report on how you were able to construct your telescope.

This activity is adapted from APEX Physics LP, Unit I, Chapter I, Lesson I Optical Instruments.

Problem Solving Sheet

Group No.: ______

Members: ______________________________

Activity Title: ______________________________

Problem: ______________________________

Type of Problem:

☐ construction ☐ discovery ☐ testing

Procedure:

What we did to solve the problem?

____

____

____

Sketch/Diagram of the Device/Model Constructed

What concepts our group considered in the construction of the device?

____

____

____

What our group found out?

____

____

____

What our group recommends to improve the design/model built?

____

____

____

V. Summary/Synthesis/Feedback

- Reflection is the bouncing of light when it hits a surface.
- Two Laws of Reflection:
  - The normal line, incident ray, and the reflected ray lie on the same plane.
  - The angle of incidence is equal to the angle of reflection.
- The reversal effect is the inversion of the image from left to right.
- Mirrors at an angle produce multiple images.
- Two Types of Reflection:
  - Specular/ Regular Reflection – reflection of light on smooth surfaces such as mirrors or a calm body of water.
  - Diffuse/ Irregular Reflection – reflection of light on rough surfaces such as clothing, paper, and the asphalt roadway.
- A curved mirror is a reflecting surface in which its surface is a section of a sphere.
- Two Kinds of Spherical Mirrors:
  - The Concave Mirror or Converging Mirror
  - The Convex Mirror or Diverging Mirror
- Important Points in Ray Diagramming:
  - Center of Curvature, C – the center of the sphere in which the mirror is part. Its distance from the mirror is known as the radius.
  - Vertex, V – the center of the mirror.
  - Focal Point/ Focus, F – the point between the center of curvature and vertex. Its distance from the mirror is known as the focal length, f.
- The 'Four Principal Rays' in Curved Mirrors
  - The P – F Ray is ray of light parallel to the principal axis, is reflected passing through the principal focus, F (concave mirror), and as if passing through the principal focus, F(convex mirror).
  - The F – P Ray is a ray of light passing through F (concave mirror) or directed towards F (convex mirror), is reflected parallel to the principal axis.
  - The C – C Ray is ray of light passing through the center of curvature, C (concave mirror) or directed towards the center of curvature, C (convex mirror) reflects back along its own path.

- V Ray is a ray of light directed to the vertex reflects at equal angle from the principal axis

- Mirror Equation:

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

- A lens is a transparent material made of glass or plastic that refracts and focuses (or that appears to focus) light rays at a point.

- Two Types of Lenses:
    - Convex Lens or Converging Lens
    - Concave Lens or Diverging Lens

- The 'Three Most Useful Rays' in Lenses:
    - The P – F Ray is ray of light parallel to the principal axis is refracted passing through the principal focus, F behind the lens (convex) or as if passing through the principal focus, F in front of the lens (concave).
    - F – P Ray. A ray of light passing through F in front of the lens(convex) or directed towards F behind the lens(concave) is refracted parallel to the principal axis.
    - V Ray. A ray of light passing through the exact center of the lens (Vertex) continue to travel in the same direction.

- The Lens Equation

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

- The Magnification Equation

$$M = \frac{h'}{h} = \frac{-q}{p}$$

VI. Summative Assessment

Directions. Choose the letter of the best answer.

1. As indicated by the hands of the clock without numbers, the real time is 9:30. What is the time indicated in its image if the clock is placed in front of a plane mirror.
   a. 2:30
   b. 3:30
   c. 9:30
   d. 10:30

2. The entire two opposite walls in your room consist of plane mirrors, how much larger will your room seem to appear?
   a. 2x larger
   b. 3x larger
   c. 4x larger
   d. infinite

3. If you stand in front of two adjacent large mirrors (at 90^{o} angle), how many images will you see?
   a. 1
   b. 2
   c. 3
   d. 4

4. If you placed a number chart in front of a plane mirror, what numbers will you read properly in the mirror?
   a. 0, 1, 6, 8, and 9
   b. 0, 1, and 6
   c. 6 and 9
   d. 0 and 8

5. An object is 6 cm in front of convex mirror with a focal length of 6 cm. What is the location of the image formed?
   a. Between F and V
   b. Between C and F
   c. In front of the mirror
   d. Can't be determined

6. A man 1.30-m tall stands 5.20 meters from a concave mirror. If the image could be formed on a screen 15.0 cm from the mirror, what is the size of the image?
   a. 0.07 cm
   b. 3.75 cm
   c. 10.5 cm
   d. 14.6 cm

7. What is the focal length of the mirror in no. 6?
   a. 0.07 cm
   b. 3.75 cm
   c. 10.5 cm
   d. 14.6 cm

8. An object is placed between a concave mirror and its focal point. What is the type and orientation of the image formed?
   a. virtual and inverted
   b. virtual and erect
   c. real and inverted
   d. real and erect

9. A light ray, traveling parallel to a concave mirror's axis, strikes the mirror's surface. What is the direction of the reflected ray?
   a. It passes through the mirror's focal point.
   b. It travels again parallel to the mirror's axis.
   c. It travels at right angles to the mirror's axis.
   d. It passes through the mirror's center of curvature.

10. An object is kept at a distance of 150 mm from a concave mirror with a radius of curvature of 600 mm. Find the image distance.
    a. -150 mm
    b. 150 mm
    c. -300 mm
    d. 300 mm

11. Why is it easier to read a newspaper than a glossy magazine?
    a. Because incident rays of light on a newspaper reflect in different directions while incident rays of light on a glossy magazine reflect in only one direction.
    b. Because incident rays of light on a newspaper reflect in only one direction while incident rays of light on a glossy magazine reflect in different directions.
    c. Because incident rays of light on a glossy magazine converge at the focus.
    d. Because incident rays of light on a newspaper converge at the focus.

12. What kind of mirror is used by department stores to give a wider area and smaller image of the shoppers/buyers?
    a. Plane mirror
    b. Convex mirror
    c. Concave mirror
    d. None of the above

13. If you look down on a pool of wavy water, you can't see your face clearly. Which one of the following gives the best explanation for this observation?
    a. Light entering the water is dispersed.
    b. Regular reflection of light happens on the surface of wavy water.
    c. Irregular reflection of light happens on the surface of wavy water.
    d. Light is reflected from the surface of water in the different direction.

14. Where should an object be placed in front of a concave mirror so that the image will have the same size as the object?
    a. At the focus
    b. At the center of curvature
    c. Between the focus and the vertex
    d. Between the center of curvature and focus

15. Which of the following is/are true of a convex mirror?
    I. It will never form a real image
    II. An inverted image will be formed if the object distance is greater than the focal length
    III. An object can be magnified if it is placed at p = 3f

    a. I only
    b. II only
    c. I and II
    d. I, II, and III

16. A light ray traveling obliquely to a convex mirror's axis, goes directly to the mirror's center of curvature before striking the mirror's surface. What is the direction of the reflected ray after hitting the mirror?
    a. It travels parallel to the mirror's axis
    b. It passes through the mirror's focal point
    c. It travels at right angles to the mirror's axis
    d. It travels back through the mirror's center of curvature.

17. What type of lens produces smaller and upright images?
    a. Concave lens
    b. Convex lens
    c. Converging lens
    d. Can't be determined

18. An object is kept at a distance of 80.00 cm from a convex lens of focal length 25.00 cm. Find the distance between its image and lens.
    a. 19.05 cm
    b. 25.25 cm
    c. 36.36 cm
    d. no image

19. A light ray, traveling parallel to the axis of a convex lens, strikes the lens. What happens to this ray after traveling through the lens?
    a. It travels crossing the axis at a point equal to twice the focal length.
    b. It travels to the axis passing between the lens and its focal point.
    c. It travels to the axis passing through its focal point.
    d. It travels parallel to the principal axis.

20. Sun's rays are observed to focus at a point behind the fishbowl near the window. The fishbowl act as what type of lens?
    a. Converging Lens
    b. Diverging Lens
    c. Focusing Lens
    d. None of the above

Glossary of Terms

Concave Lens	a kind of lens that is thicker at the edges and thinner in the center. It is called a diverging lens.
Concave Mirror	a curved mirror in which the reflective surface bulges away from the light source. It is called a converging mirror.
Convex Lens	a kind of lens that is thicker in the center than the edges. It is called a converging lens.
Convex Mirror.	a curved mirror in which the reflective surface bulges towards the light source. It is called a diverging mirror.
Plane Mirror	a polished or smooth surface (as of glass) that forms images by reflection.
Reflection of Light	the bouncing of light rays when it hits a surface.
Refraction of Light	the bending of light rays when passing obliquely from one medium into another.

References and Links

Printed Materials:

Belen, J.G., A.I Yap, E.B Ogena, and A.I Yap. *Addressing Misconceptions in Mathematics and Science*. Quezon City: NISMED UP Diliman and DOST-SEI.

Littell, McDougal. *Science, Integrated Course 1, Teacher's Edition*. Evanston, Illinois: McDougal Littell, 2005.

Padua, Alicia, and Ricardo Crisostomo. *Laboratory Manual and Workbook in Physics*. Vibal Publishing House, Inc., 2011.

Shipman, James, Jerry Wilson, and Charles Higgins, Jr. *An Introduction to Physical Science*. Pasig City: Cengage Learning Asia Pte Ltd (Philippine Branch), 2013.

Young, H. D., Freedman, R. A., Ford, A. L. (2012), Sears and Zemansky's University Physics with Modern Physics – 13th Ed., San Francisco: Addison-Wesley Pearson Education, Inc.

Science and Technology Textbook for Fourth Year, Revised Edition, 2004, SEMP.

Electronic Sources:

Henderson, Tom, . The Physics Classroom, “Specular vs. Diffuse Reflection.” Accessed March 1, 2014. http://www.physicsclassroom.com/class/refln/u13l1d.cfm.

The Mirror Equation. Accessed June 21, 2014. http://www.physicsclassroom.com/class/refln/Lesson-3/The-Mirror-Equation

Ray Diagram – Concave Mirrors. Accessed June 22, 2014. http://www.physicsclassroom.com/Class/refln/U13L3d.cfm#note

Ray Diagram – Convex Mirrors. Accessed June 22, 2014. http://www.physicsclassroom.com/class/refln/Lesson-4/Ray-Diagrams-Convex-Mirrors

Diverging Lenses – Ray Diagrams. Accessed June 23, 2014. http://www.physicsclassroom.com/class/refrn/Lesson-5/Diverging-Lenses-Ray-Diagrams

Physics Questions. Accessed October 15, 2014. http://www.sciencequiz.net/lcphysics/light/mcq/reflection/reflection1a.htm

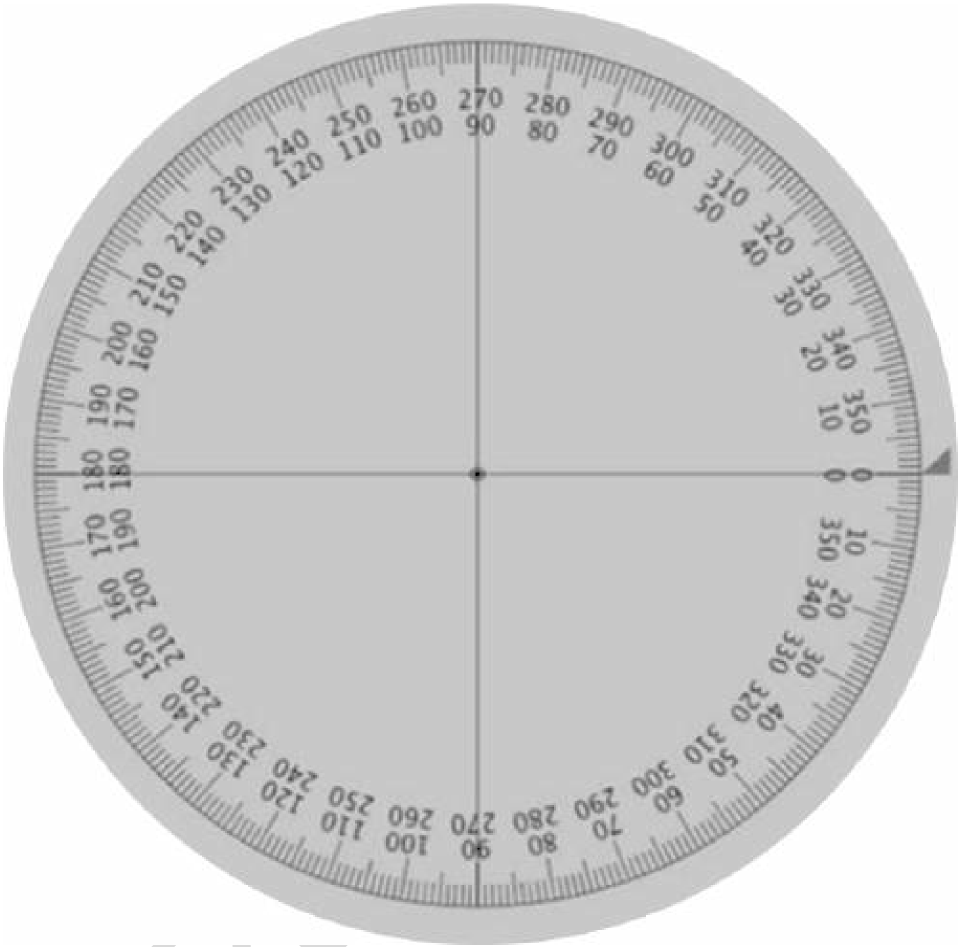
http://www.wallpaperup.com/225284/landscape_nature_trees_mountain_Mount_Mayon_Philippines_Luzon_reflection_volcano_g.html

http://www.orcagrowfilm.com/Articles.asp?ID=148

http://www.wallpaperup.com/29790/sunset_mountains_reflection.html

http://www.education.com/science-fair/article/how-many-images-make-mirrors/

Appendix A



A Paper Protractor

10

Science

Learner's Material
Unit 3

This book was collaboratively developed and reviewed by educators from public and private schools, colleges, and/or universities. We encourage teachers and other education stakeholders to email their feedback, comments, and recommendations to the Department of Education at action@deped.gov.ph.

We value your feedback and recommendations.

Department of Education
Republic of the Philippines

Science – Grade 10
Learner's Material
First Edition 2015

Published by the Department of Education
Secretary: Br. Armin A. Luistro FSC
Undersecretary: Dina S. Ocampo, PhD

Development Team of the Learner's Material

Authors: Herma D. Acosta, Liza A. Alvarez, Dave G. Angeles, Ruby D. Arre, Ma. Pilar P. Carmona, Aurelia S. Garcia, Arlen Gatpo, Judith F. Marcaida, Ma. Regaele A. Olarte, Marivic S. Rosales, Nilo G. Salazar
Reviewers: Eligio C. Obille Jr., Marlene B. Ferido, Ma. Helen DH Catalan, Vic Marie Camacho, Lilia M. Rabago, Cerilina M. Maramag
Illustrators: Joseph V. Bales, Ramon C. Gatpo, Regaele A. Olarte, Marivic S. Rosales, Ruel C. Quindoy, Antonio I. Basilla, Jose Leo Vic O. Albaño
DepEd Specialists: Joseph R. Jacob, Maria Amparo R. Ventura
Photo Credits: Herma D. Acosta, Dave G. Angeles, Liza A. Alvarez, Ruby D. Arre, Aurelia S. Garcia, Judith F. Marcaida, Regaele A. Olarte, Jane Chavarria, Nilo G. Salazar
Layout Artists: Matthew Daniel V. Leysa and Mary Grace Ann G. Cadisal

Printed in the Philippines by REX Book Store, Inc.
Department of Education-Instructional Materials Council Secretariat (DepEd-IMCS)
Office Address: 5th Floor Mabini Building, DepEd Complex
Meralco Avenue, Pasig City
Philippines 1600
Telefax: (02) 634-1054, 634-1072
E-mail Address: imcsetd@yahoo.com

TABLE OF CONTENTS

Module3: Biodiversity and Evolution

Module 4: Ecosystem: Biodiversity

UNIT 3

Living Things and Their Environment

UNIT 3: Living Things and Their Environment

Overview

In the past years, you have studied about the coordinated functions of the digestive, respiratory, and circulatory systems. You have learned that nutrients enter the bloodstream and combine with oxygen taken in through the respiratory system. You have also understood the structure of genes and chromosomes, and the functions they perform in the transmission of traits from parents to offspring. You have discovered that some species that once existed are now extinct, and that they become extinct when they fail to adapt to changes in the environment. You have become familiar about how plants capture energy from the sun and store energy in sugar molecules through photosynthesis, and learned that stored energy is used by cells during cellular respiration. You have found out that these two processes are interrelated.

All modules in **Grade 10 Unit 3 Living Things and Their Environment** present mental and hands-on activities that will enable you to apply science concepts and inquiry skills in addressing real-world problems through scientific investigations. These instructional activities are designed to enhance your knowledge, understanding, skills, and ability to transfer learning. There are four modules in this quarter, namely:

Module 1: Coordinated Functions of the Nervous, Endocrine, and Reproductive Systems

Module 2: Heredity: Inheritance and Variation

Module 3: Biodiversity and Evolution

Module 4: Ecosystems: Biodiversity

At the end of Grade 10, you should have already developed scientific, technological, and environmental literacy that will lead you to rational choices on any issue that you will face in life.

Suggested time allotment: 12 to 14 hours

Unit 3
MODULE
1

COORDINATED FUNCTIONS OF THE NERVOUS, ENDOCRINE, AND REPRODUCTIVE SYSTEMS

I. Introduction

The human body is made up of different systems that coordinate with one another in order to perform their functions well. If any part of these organ systems malfunctions, the body will become unbalanced. The instability caused by the malfunctioning of one system cannot be made stable by other systems because each system has its own function in the body. You have studied in the past that human body systems are the combined functional units composed of various organs that work in full coordination with one other. In Grade 9, you have already studied how the circulatory and respiratory systems work together and how lifestyle affects these systems. Now you will learn about the coordinated functions of the reproductive, endocrine, and nervous systems.

As you go through this module, you will be able to understand organisms having feedback mechanisms, are coordinated by the nervous and endocrine systems. You will also learn how these feedback mechanisms help organisms maintain homeostasis to reproduce and survive.

II. Learning Competencies/Objectives

At the end of this module, you are expected to:

1. Describe the parts of the nervous, endocrine, and reproductive systems, along with their functions.
2. Explain the role of hormones involved in the female and male reproductive systems.
3. Describe the feedback mechanisms in regulating processes in the female reproductive system.
4. Describe how the nervous system coordinates and regulates feedback mechanisms to maintain homeostasis.

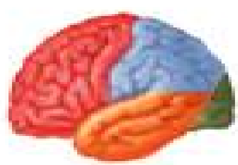
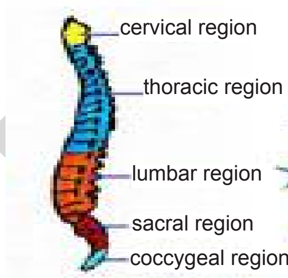
In Module 1, you will answer the following key questions:

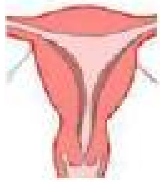
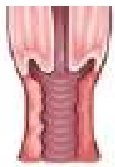
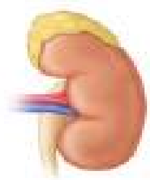
- How do the nervous, endocrine, and reproductive systems perform coordinated functions?
- How do hormones work to regulate various mechanisms inside the human body?
- How do feedback mechanisms help organisms to maintain homeostasis in order to reproduce and survive?

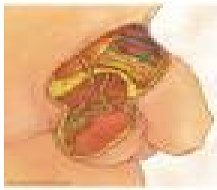
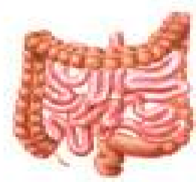
III. Pre-Assessment

Odd Organ Out

Directions: Study each set of diagrams showing different organs of the human body. Then, determine which organ does not belong to the group by naming it on the space provided, on the second column of the table. Lastly, write your explanation on the third column why the organ should not be included in the group.

Group of Organs	Odd-One Out	Reason
 good-health-guide. blogspot.com  eweb.furman.edu  education-portal.com  ninds.nih.gov		

Group of Organs	Odd-One Out	Reason
 medindia.net  myoptumhealth.com  wisegeek.org  academymedical.com		
 globehealingcenter.com  hormone.org  tooloop.com  facstaff.gpc.edu		

 sandrocastelli.com  tooloop.com  health.allrefer.com  Lackfoundation.org		

You have studied that cells make up a tissue, then tissues make up an organ, and organs make up a system. Now, you will first try to understand the organ system before you go to the cellular level to know how the individual cells of the nervous system work.

IV. Reading Resources and Instructional Materials

The Nervous System

The Structure of the Nervous System

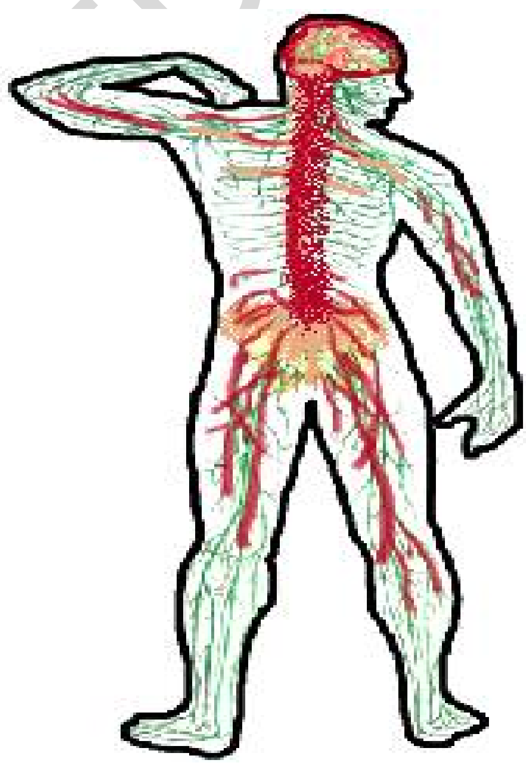


Figure 1. The human nervous system

Your nervous system connects all your body parts and transmits signals from one part to another. It is a system of cells, tissues, and organs that regulates the body's responses to internal and external stimuli. Each part of the nervous system has a specific role as it functions as an important part of a system.

Major Divisions and Parts of the Nervous System

1. **Central Nervous System (CNS)**
   The CNS serves as the main processing center for the entire nervous system. It consists of two main components, namely the:

   a. Brain
   This is an organ located within the skull that functions as organizer and distributor of information for the body.
   It has three main parts:

   Cerebrum – large, upper part of the brain that controls activity and thought.

   Cerebellum – the part under the cerebrum that controls posture, balance, and coordination.

   Brain Stem – the part that connects the brain to the spinal cord and controls automatic functions such as breathing, digestion, heart rate, and blood pressure.

   b. Spinal Cord
   This serves as a channel for signals between the brain and the rest of the body, and controls simple musculoskeletal reflexes without input from the brain.

1. **Peripheral Nervous System (PNS)**
   The PNS connects the central nervous system to the organs and limbs. It has two main divisions:

   a. Somatic Nervous System
   This system is associated with the voluntary control of body movements and has two main parts:

   Spinal Nerves – the nerves that carry motor and sensory signals between the spinal cord and the body.

Cranial Nerves – the nerve fibers that carry information into and out of the brain stem

b. Autonomic Nervous System

This system is associated with the involuntary control of body movements and has two subdivisions:

Sympathetic - it is activated when the body is in a dynamic role or stress. (e.g., increased heart rate and breathing, dilation of pupil, sweating, etc.)

Parasympathetic - it maintains body functions and restores the body to normal or relaxed mode.

Now, test your understanding of the basic organization of the nervous system by doing Activity1.

Activity 1

Break it Down!

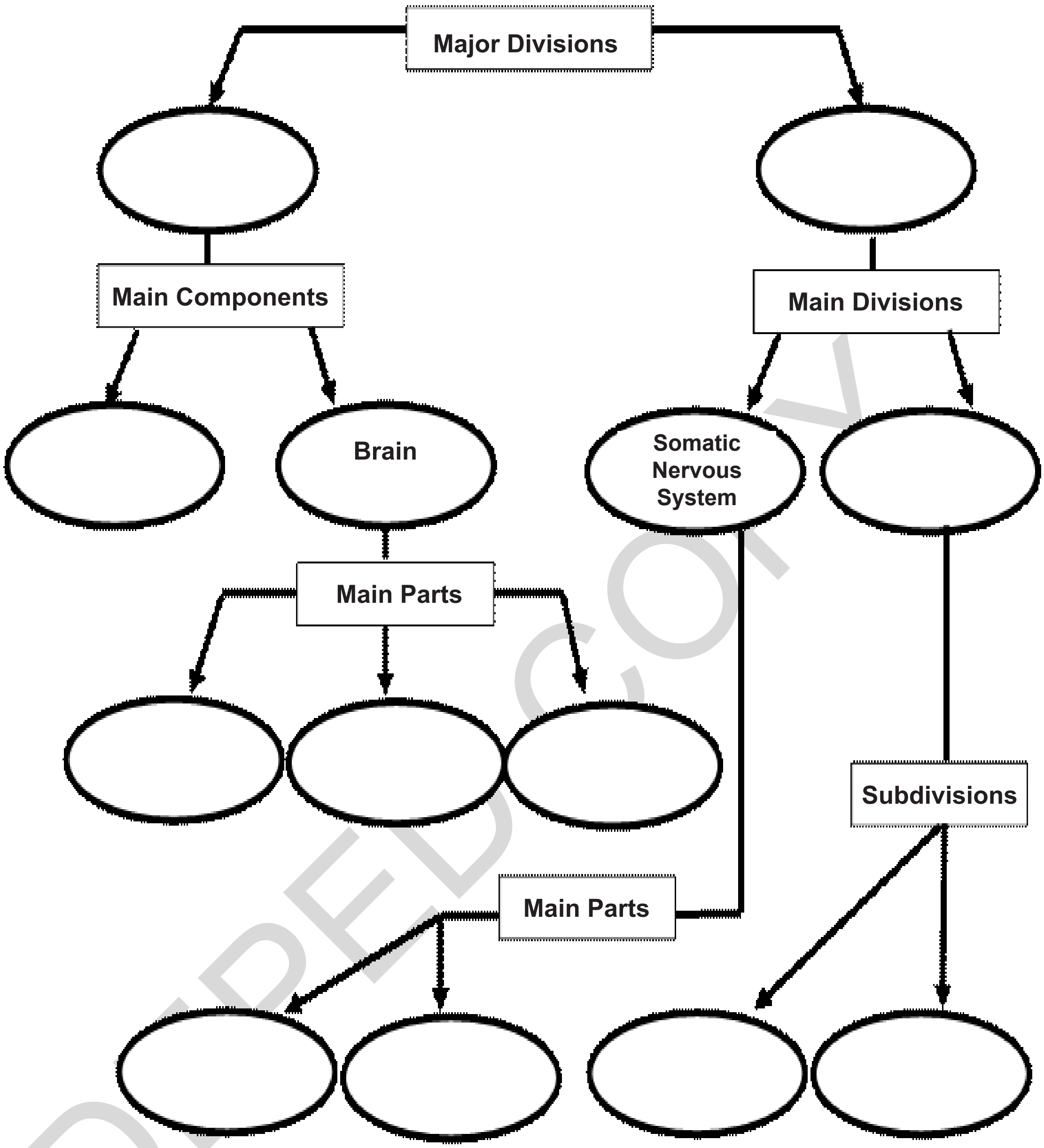
(Adapted from DepEd Project EASE, Module 9: Life Support Systems, pp. 4-6)

Objective:

Identify the parts of the nervous system

Procedure:

Using the given graphic organizer, fill in the missing parts to complete the entire concept showing the structure of the nervous system.



Guide Questions:

Q1. How will you differentiate the Central Nervous System (CNS) and the Peripheral Nervous System (PNS) in terms of their functions?

Q2. What might happen to the human body if one part of the nervous system fails to carry out its function properly?

The Nerve Cell

The basic unit of the nervous system is the nerve cell. Nerve cells are called neurons. Study Figure 2 and look at the different parts of the neuron. There are billions of neurons in the body. Some exist alone. Others are joined together to form organs like the brain and spinal cord.

There are twelve to fourteen billions of neurons in one part of the brain alone. A neuron has a cell body containing the nucleus. Projecting out from the cell body are root-like structures. These are the dendrites and axons. Dendrites carry impulses towards the cell body. A cell may have as many as 200 dendrites carrying impulses toward the cell body. A single dendrite can be over one meter long. Axons carry impulses away from the cell body. Axons pass impulses to the dendrites of other neurons or cell body of muscle cells. Axons can be grouped together into cable-like bundles called nerves.

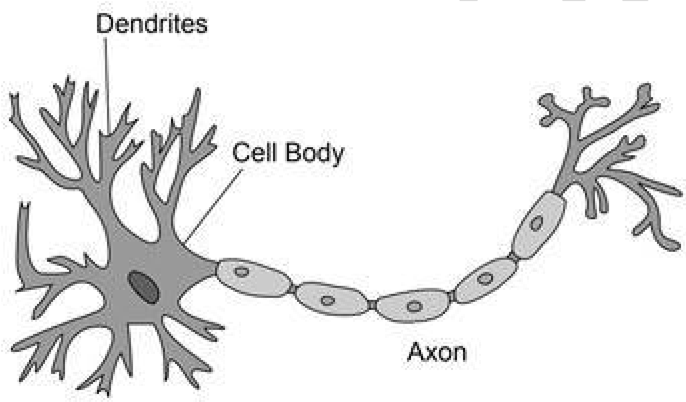


Figure 2. The basic parts of a neuron

Control of Body Processes through the Nervous System

The Nerve Impulse

Neurons are cells with the special ability to carry signals or impulses. Thoughts, emotions, learning, and many body functions are carried by nerve impulses in the neurons. A nerve impulse is a combination of an electrical charge and a chemical reaction. A nerve impulse is not a flow of electricity, but an electrochemical signal moving along a neuron.

Imagine that you have a board with a row of switches. Quickly click each switch in the row on and off. This will give you an idea of how a nerve impulse travels along a neuron.

A nerve impulse cannot jump from one neuron to another. When a nerve impulse comes to the end of an axon, it produces the chemical, called neurotransmitter, to be released. The chemical crosses the space between neurons called synapse and stimulates the nerve impulse to start in the next dendrite.

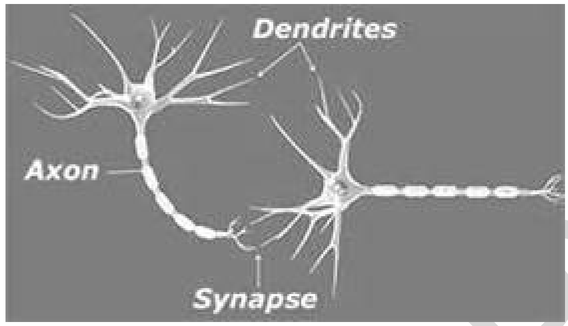


Figure 3. The nerve impulse is sent by neurotransmitters from one neuron to another through a gap called synapse

The nervous system is assisted by five sense organs - the eyes, ears, nose, tongue, and skin. These sense organs are constantly receiving information from the environment and sending messages to the brain. These senses aid in the survival of human beings. A stimulus (plural: stimuli) is any factor in the environment that may trigger a nerve impulse. A response is a reaction to a stimulus. A stimulus is received by the body and a response is made. An organism must be able to respond to a stimulus in order to survive.

Messages do not travel in both directions along the same neuron. Only the axon of the neuron releases neurotransmitters that cross the space between neurons. Reaction time is the length of time between application of a stimulus and detection of a response.

The next activity that you will perform will enable you to understand these concepts better. Use your body's senses to detect the stimuli in your environment and execute the corresponding response.

Activity 2

How Fast is Your Reaction?

(Adapted from DepEd Project EASE, Module 9: Life Support Systems, pp. 7-8)

Objective:

- Measure the length of time of response to catch a dropped object

Materials:

- metric ruler
- data chart

Procedure:

1. Construct a table like the one given below, to record your data.

Trials	Centimeters where the ruler fell			
	Eyes open		Eyes closed	
	Left hand	Right hand	Left hand	Right hand
1st				
2nd				
3rd				
4th				
5th				
Average				

2. Have your partner hold a metric ruler at its end with the highest number in cm.

3. Place the thumb and forefinger of your left hand close to, but not touching, the end with the lowest number.

4. When your partner drops the ruler, try to catch it between your thumb and finger.

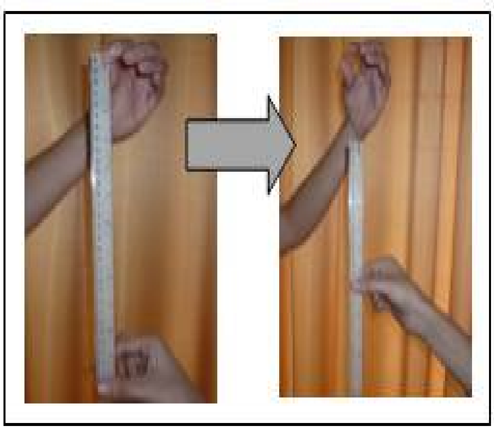


Figure 4. Measuring the reaction time

5. Record where the top of your thumb is, when you catch the ruler. This number gives how many centimeters the ruler fell.

6. Repeat steps 2 to 5 five more times and record the measurements on the data table that you have constructed earlier.

7. Repeat steps 2 to 5 five more times using your right hand to catch the ruler.

8. Repeat steps 2 to 5 five more times using your left hand with your eyes closed. Your partner will signal you by saying “now” when the ruler drops.

9. Repeat steps 2 to 5 five more times using your right hand with your eyes closed. Record your data and observations.

10. Exchange tasks and drop the ruler for your partner.

11. To complete your data chart, change all the centimeters to seconds by multiplying by 0.01.

12. After recording all the data, compute for the average by adding up the measurements of all the trials and dividing it by the number of trials.

Guide Questions:
(Answers will depend on whether the person is left-handed or right-handed)

Q3. With which hand did you catch the ruler faster when your eyes were open?

Q4. With which hand did you catch the ruler faster when your eyes were closed?

Q5. Did you catch the ruler faster with your eyes open or closed?

Q6. Explain why a message moving along nerve pathways takes time.

Q7. Describe the nerve pathway that the message followed when you saw the ruler fall.

KEY CONCEPTS:

Neurons have the special ability to carry signals or impulses. A nerve impulse is an electrochemical signal moving along a neuron. The space between neurons is called synapse. A stimulus is any factor in the environment that influences behavior. A response is a reaction to a condition or stimulus. An organism must be able to respond to a stimulus in order to survive. Reaction time is the length of time between application of a stimulus and detection of a response.

Did you know that your brain works round the clock for as long as you live? Your brain does not only control your thoughts, emotions, and movements but also numerous things that you are less aware of such as your breathing, your heartbeat, and even the stress that you feel.

How does your nervous system work? This system is like a network that relays messages back and forth from the brain to various parts of the body. It transmits information through the spinal cord, which extends from the brain down through the back and consists of fine nerves that branch out to every organ and body part. When a message reaches the brain from any part of the body, the brain commands the body to respond. You can think of your nervous system as a relay team where one runner passes the object to another runner. Relatively, you have nerve cells handing its information to the next cell, which passes the information to another cell. Finally, the information reaches into its destination and a reaction takes place. For instance, if you hold a rose stem and accidentally prick your fingers, the nerves in your skin release a message of pain to your brain. Your brain, in response to the signal, commands the muscles in your hand to pull away. This split second relay inside your body happens in a much shorter period than it took you to read about it.

Neurons are specially intended for information processing and signaling. They relay and receive messages (impulse) between the brain and body, and within the brain and spinal cord. Motor neurons transmit impulses from the brain to muscles, glands, or other neurons in the Peripheral Nervous System (PNS).Sensory neurons transmit impulses from sensory nerves (receptor cells) to the Central Nervous System (CNS).

Do the next activity to understand how the nervous system controls body processes.

Activity 3

A Nervous Trip

Objective:

Explain how the body processes are controlled through the nervous system

Procedure:

1. Form a team of 8 to 10 students and compete with the other groups in your class.
2. Among the members of the group, assign students who will represent the following parts: Brain, Organ, Sensory Neurons, and Motor Neurons
3. Have the “Brain” stand at one end of the classroom, and the “Organ” at the other end near the blackboard.
4. Let three to four members representing “Sensory Neurons” stand and line up between the “Brain” and the “Organ.” Another set of three to four members representing “Motor Neurons” will stand and line up facing the “Sensory Neurons.”
5. Refer to the following illustration to see how you will position yourselves in the game.

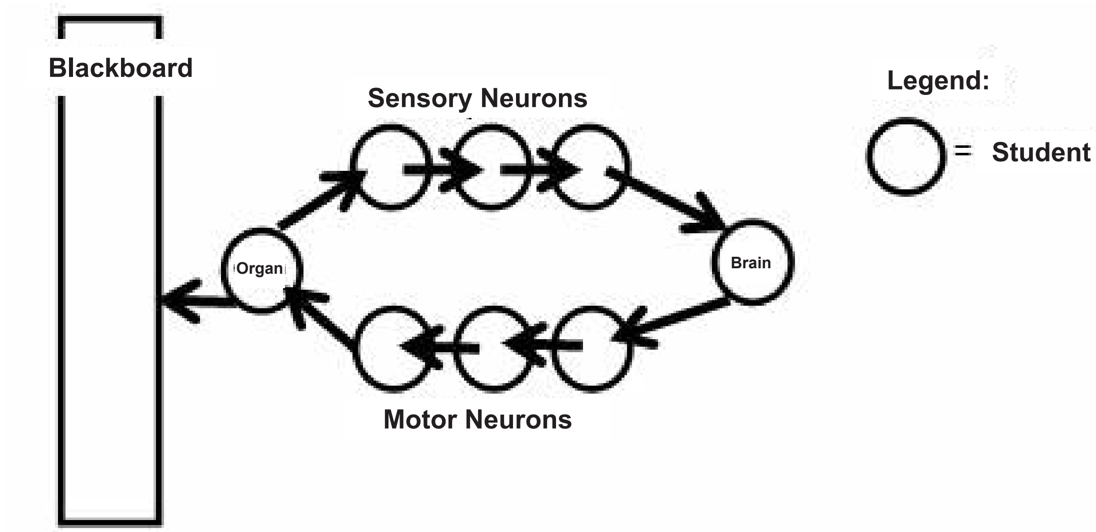


Figure 5. The game setup showing the relay course from start to end

6. Your teacher will show a card to the first member of the group, who is the "Organ." Each card will depict a situation of a stimulus affecting an organ.

7. The "Organ" must pass the message to one "Sensory Neuron" by whispering.

8. Each member who receives the message must relay it to another until it reaches the last "Sensory Neuron."

9. Let the last person in the "Sensory Neuron" group run to the "Brain" to communicate the message that was transmitted from the "Organ."

10. The "Brain" must think of a reaction to the stimulus presented and pass this response to the "Motor Neurons."

11. Each member of the "Motor Neuron" group who receives the response from the brain, must relay it to another until it reaches the last person in the group.

12. The "Organ" will receive this response through the "Motor Neurons" and run quickly to the board to write the response.

13. The team with the most acceptable answer and the shortest time of trip will win the game.

Guide Questions:

Q8. How does the brain receive the information from the receptor?

Q9. What does the brain do as soon as it receives the information?

Q10. How is the message from the brain sent in response to the stimuli?

Q11. How will you differentiate the sensory and motor neurons based on their functions?

Q12. Based on the simulation activity, explain how information travels in the nervous system.

Q13. Why does the damage in the nervous system cause paralysis of the body?

Q14. What public health care programs in your locality are geared towards dealing with health issues concerning the nervous system?

KEY CONCEPTS:

When a receptor such as an organ perceives a stimulus, the impulse is sent to the brain by the sensory neurons, which then transmit information from one nerve cell to another. As the message reaches the brain, it processes the information and commands an effector such as a muscle or an organ to respond. The message coming from the brain is sent through the motor neurons.

Suggested Enrichment Activities

1. During the first three years, a child's brain triples in weight and establishes approximately 1,000 trillion nerve connections. Thus, the child's experiences during the first three years of life are crucial to brain development. Gather and write down information about the different ways of stimulating brain development in children.

2. Design a flyer that will disseminate information about the different diseases affecting the human nervous system.

Similar to the nervous system, the endocrine system controls and regulates body processes. Generally, the endocrine system is in control of the mechanisms in the body that slowly take place, such as cell growth. Rapid processes, such as body movement and breathing, are controlled by the nervous system. Although these two systems are different, they work together in a coordinate manner to enable the body to function properly. After studying about the nervous system, now you will learn about the endocrine system, its functions, and the glands that comprise the system.

The Endocrine System

Function of Endocrine System

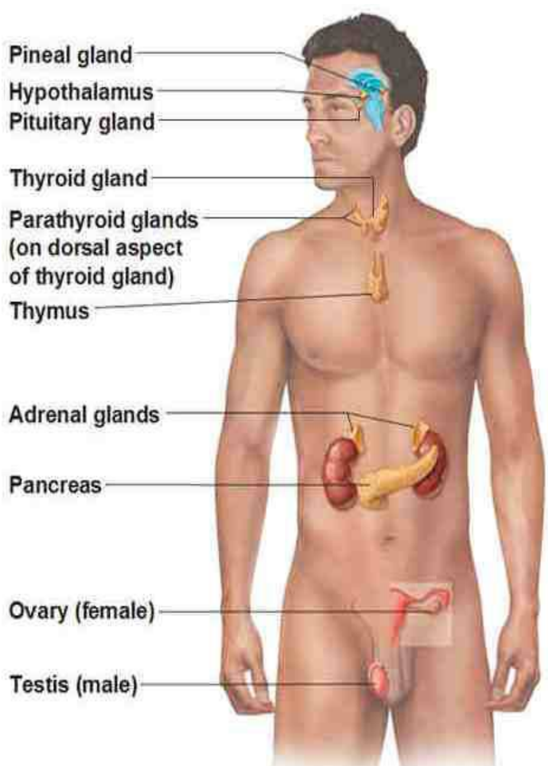


Figure 6. The major endocrine organs in the body

The endocrine system is composed of glands that secrete different types of hormones that affect almost every cell, organ, and function of our body. It is essential in regulating growth and development, metabolism, as well as reproductive processes and mood.

How does your endocrine system function? Endocrine glands secrete chemicals known as hormones into the bloodstream, which carries them throughout the body. When a hormone in the blood reaches the target organ, it produces a notable effect. The endocrine system sends signals all over the body, much like the nervous system, but unlike the instant responses activated by the nervous system, the effects can take a few hours or even weeks.

Endocrine Glands and Their Hormones

The endocrine system contains a group of glands that release hormones into the body. The following table lists all the major glands in the body, with their functions, locations, and the hormones they release.

Gland	Location	Hormones Released	Function
Pituitary	at the base of the brain	Oxytocin, Vasopressin, Growth Hormone, Adrenocorticotropic Hormone (ACTH), Prolactin, Luteinizing Hormone, Follicle Stimulating Hormone (FSH)	stimulates growth, and controls the functions of other glands
Thyroid	below the voice box	Thyroxin, Calcitonin	regulates body metabolism, and causes storage of calcium in bones
Parathyroid	in the neck	Parathyromone	controls the calcium levels in your body, and normalizes bone growth
Thymus	in front of the heart	Thymosin	enables the body to produce certain antibodies
Adrenal	on top of the kidneys	Adrenaline	prepares the body for action, controls the heart rate and breathing in times of emergency
Pancreas	between the kidneys	Insulin, Glucagon	regulates blood sugar levels
Reproductive -Testes (Males) -Ovaries (Females)	lower abdomen lower abdomen	Androgen, Testosterone Estrogen, Progesterone	control maturation and male characteristics influence female traits, and support reproductive function

Now that you are familiar with the different glands in the human endocrine system, you can already perform the following activity.

Activity 4

Who's in Control?

Objective:

Identify the major endocrine glands in the human body and their functions

Procedure:

Study each picture that depicts the involvement of a particular gland in the endocrine system. Write down the name of the endocrine gland and explain its effect, according to its function.

Example

Thyroid Gland
It regulates the metabolism of the body.

Athletes burn up calories during exercise.

1.

A pregnant woman

2.

A boy running away from danger

3.

A kid growing taller

4.

A sick person in bed

5.

A girl eating sweets

Guide Questions:

Q15. Which gland of the endocrine and nervous system controls the other glands in the body?

Q16. How will you differentiate thyroid and parathyroid glands in terms of location and function?

Q17. If a person's blood sugar level becomes unstable, what glands might be involved in the problem?

Q18. How important is the thymus gland in keeping your body free from diseases?

Q19. What might happen to a person born without a thymus gland?

Q20. How will you explain the sudden boost of energy, increased strength and extraordinary ability to lift very heavy objects especially during emergency situations?

Q21. Why is injecting insulin an essential part of the daily regime for most people with diabetes?

Q22. Why does the menstrual cycle stop during menopause?

Q23. How do oral contraceptives, specifically birth control pills, prevent pregnancy?

Q24. Breastfeeding releases oxytocin and prolactin, hormones that relax the mother and make her feel more nurturing toward her baby. On the other hand, how does the baby benefit from the production of these hormones in the mother's body?

KEY CONCEPTS:

The endocrine system consists of glands that secrete chemicals called hormones to control various body processes. This control system usually brings about slow changes in the body because chemical messengers move more slowly than nerve impulses. The major glands in the body are the pituitary, thyroid, parathyroid, thymus, adrenal, pancreas, ovaries, and testes.

Effects of Hormones in the Body

Several processes in the body are coordinated by hormones which regulate and balance the working of organs, tissues, and cells. The endocrine system influences how your heart beats, how your bones and tissues develop, and even your capacity to have a baby. It plays an essential role in the occurrence of disorders such as diabetes, thyroid disease, growth disorders, and/or sexual dysfunction.

Both men and women produce hormones in the same areas with one exception, the reproductive glands. Additional male hormones are produced in the testes while female hormones are produced in the ovaries.

Some hormones have short-term effects while other hormones have long-term effects such as those that control our growth and the changes at the onset of puberty. During puberty, there are many hormonal changes that happen in your body. One moment you laugh, and then suddenly you feel like crying. Sudden mood swings are relatively caused by the increasing amount of hormones in the body at this stage. It is therefore important to maintain a positive outlook in life and remember that these changes are only temporary and will stabilize with time.

Hormones act in very small amounts. If the organ and hormones do not produce the regulated amount of chemicals to your body, it may result in an abnormality of your body. This condition is called hormonal imbalance. An increase or decrease in its amount may have a significant effect in the human body.

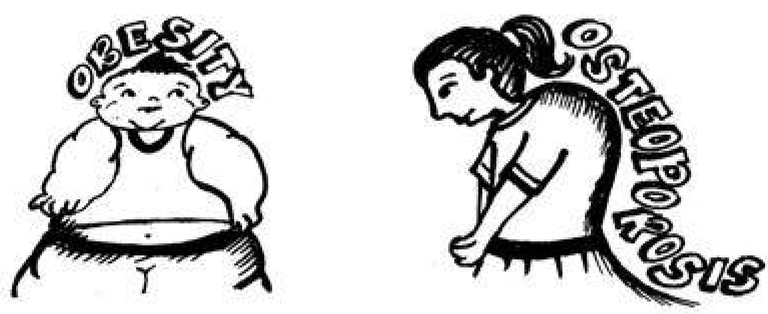


Figure 7. Disorders due to endocrine dysfunction

The next activity will get you acquainted with the different disorders in the endocrine system due to hormonal imbalance and the hormones responsible for them.

Activity 5

What Went Wrong?

Objective:

Explain the effect of a particular hormone in the body if not properly regulated

Procedure:

A. Identify which gland in the endocrine system is involved in each dysfunction and explain the effect of hormonal imbalance that was observed.

1.

http://www.picturehistory.com/

Dwarfism

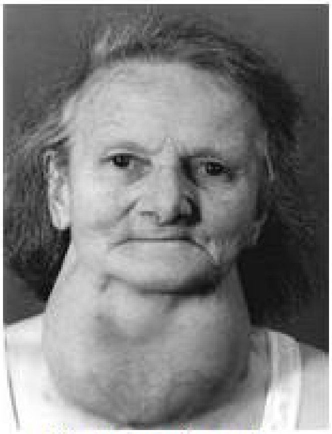
____
____
____
____
____

2.

http://www.bigfootbuzz.net/

Gigantism

____
____
____
____
____



http://www.gfmer.ch

Goiter

B. Write a one-paragraph essay about how one of these conditions will affect your life if you have dysfuntion due to the effect of hormonal imbalance

Guide Questions:

Q25. What condition may arise if the pituitary gland is not producing enough growth hormones?

Q26. What will happen to a person with excessive secretion of growth hormones from the pituitary gland?

Q27. Why is there a noticeable swelling in the front part of the neck of a person who has goiter?

Q28. How does using iodized salt help in preventing thyroid problems?

Q29. How does the medical condition of a person with endocrine dysfunction affect his or her way of life?

KEY CONCEPTS:

Hormones affect various processes in the body as they regulate and balance the functioning of organs, tissues, and cells. Hormones have great impact on your growth, appearance, emotions, and reproductive functions. These determine whether or not you develop disorders such as diabetes, thyroid disease, growth disorders, or sexual dysfunction. Hormones act in very small amounts. An increase or decrease in hormonal levels may result in body disorder due to hormonal imbalance.

For most living creatures, reproduction is basically a normal process controlled by hormones. Even though human reproduction is also controlled by hormones, the process is rather more complicated. Unlike other organisms such as plants and animals, you can make decisions about reproduction. What influence these decisions are your values, emotions, expectations, and goals. However, like any other living things, humans depend on reproduction for the survival of the species. If people stop to reproduce, the human species would become extinct.

The Reproductive System

The system involved in sexual reproduction is called the reproductive system. There is a striking difference between the male and the female reproductive systems, although they also share a number of similarities. For example, the reproductive organs of the male and female are developed from the same embryological structures, and some hormones are commonly found in both male and female, in varying quantities and produce different responses

The Male Reproductive System

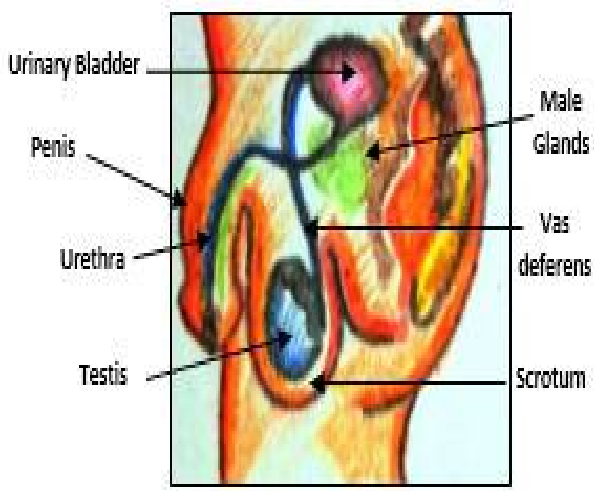


Figure 8. Parts of the Male Reproductive System

Examine the diagram of the male reproductive system. Figure 8 shows the main parts of the male reproductive system. The cross-sectional side view of the reproductive system shows that certain parts of the male reproductive system are also part of the excretory system.

Be familiar with the specific functions of each basic part using the table below:

Part	Function
Testis	Produces sperm cells
Scrotum	Sac of skin that holds the testis
Penis	Deposits sperms into the vagina during mating
Vas deferens (tube)	Carries sperm from testes to urethra
Urethra	Carries sperm and urine out of the body
Glands a. seminal vesicle b. prostate gland c. bulbourethral gland	Provide liquid in which sperm can swim - Secretes a fluid that makes up most of the components of the semen - Secretes a slightly alkaline milky fluid that is discharged as part of the semen - Secretes a thick and clear mucus that lubricates and neutralizes the any trace of acidic urine in the urethra

The Female Reproductive System

The female reproductive system has the following functions:

1. Produces female sex cells
2. Receives sperm cells from the male
3. Nurtures the development of and provides nourishment for the new individual

Examine the diagram on Figure 9 which shows the front view of the female reproductive system. The female reproductive system consists of the ovaries, oviducts (Fallopian tubes), uterus, vagina, and external genitalia. The internal reproductive organs of the female are located within the pelvis, between the urinary bladder and rectum. The uterus and the vagina are in the middle part, with an ovary on each side of the uterus.

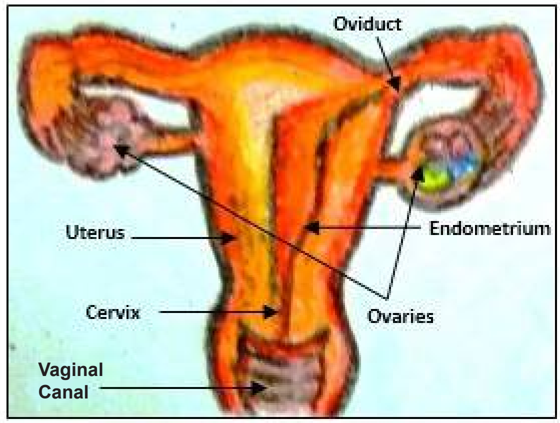


Figure 9. Parts of the Female Reproductive System

Now, study the function of each part.

Part	Function
Ovary	produces egg cells
Oviduct	serves as passageway of eggs from the ovary to the uterus; site of egg fertilization
Uterus	serves as site of egg implantation; is where the fertilized egg develops
Vagina	receives the penis of male during mating

Puberty involves the onset of sexual maturity and the ability to reproduce. When a female reaches puberty, egg cells start to develop in her ovaries that produce the sex cells. It is also the time when the body develops the capacity to conceive.

The Role of Hormones in Female and Male Reproductive Systems

The male reproductive system also has prostate glands. Chemicals from these glands nourish the sperm cells and help them mature.

The production of sperm cells and the release of semen can be regulated by hormones or special chemicals that come from the testis, the brain and the pituitary gland (refer to Figure 10A). These hormones keep the reproductive system properly functioning.

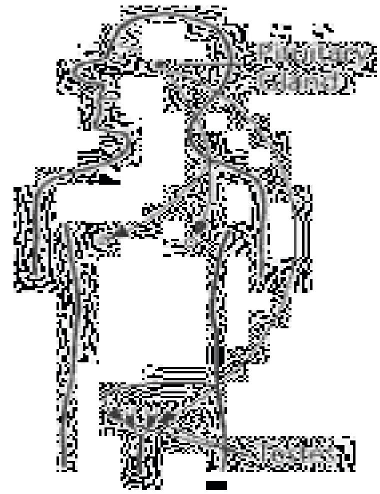


Figure 10A. Pituitary gland controls the function of the testes.

The female reproductive system, just like the male reproductive system, is also regulated by hormones. The follicles produce hormones that control the growth and release of eggs from the ovaries. While other hormones prepare the uterus so a baby can grow in it, other hormones still control the stretching of the uterus during pregnancy.

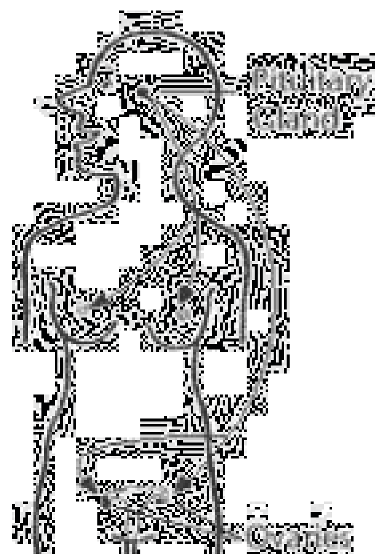


Figure 10B. Pituitary gland controls the function of the ovaries.

KEY CONCEPTS:

Hormones play an important role in both male and female reproductive systems. The pituitary gland controls the functions of both the testes and the ovaries. These hormones keep the reproductive system properly functioning.

Feedback Mechanisms Involved in Regulating Processes in the Female Reproductive System

The Menstrual Cycle

We have learned that, on average, an ovary releases only one egg every 28 days. Now, what controls this timing? Hormones control many of the changes in the reproductive system. Remember that hormones are chemicals that affect certain body organs. The monthly changes that take place in the female reproductive system are called menstruation. This cycle occurs every month from the first onset which could happen when a female is between 10 to 13 years old. The monthly cycle continues for about 40 years. Refer to Figure 11 for a clearer explanation of the different events that take place in the cycle. Just follow numbers 1-10 in proper order.

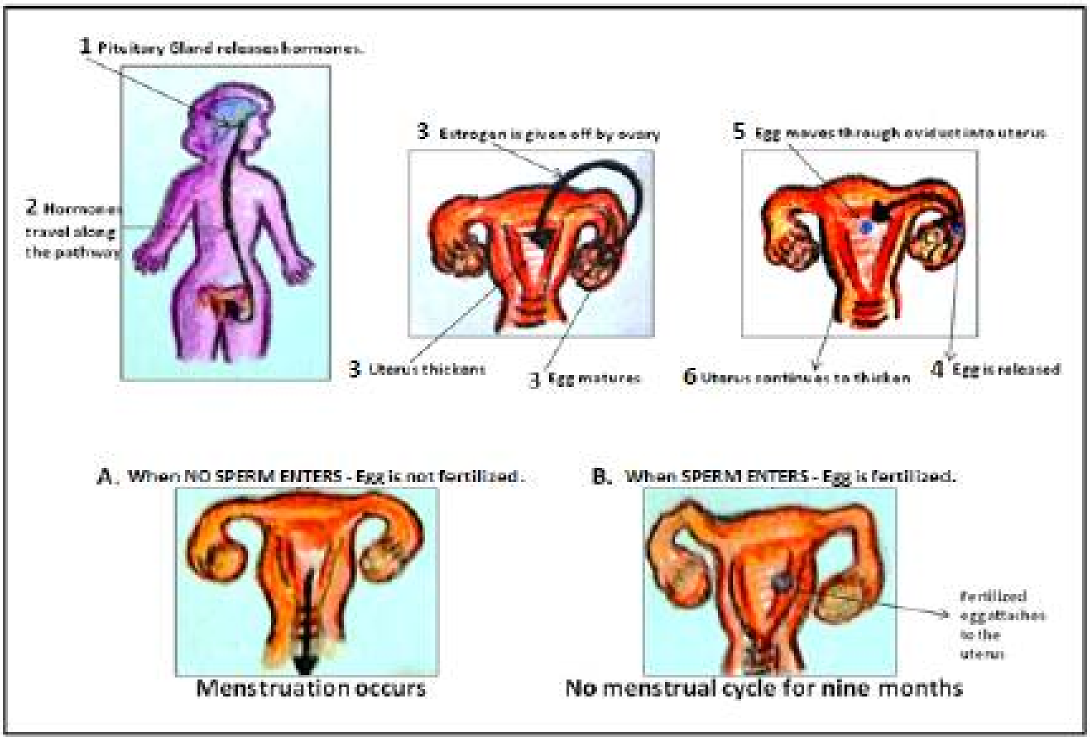


Figure 11. The menstrual cycle

To summarize, the important events during the menstrual cycle are as follows:

1. The pituitary gland controls and starts the cycle.
2. The pituitary gland releases hormones that cause the egg in the ovary to mature. The luteinizing hormone (LH) initiates the maturation of the follicles, converts ruptured follicles into corpus luteum and causes the secretion of progesterone. The follicle stimulating hormone (FSH) assists in the maturation of the follicles and causes the secretion of estrogen from the follicles.

3. Meanwhile, the ovary itself releases a hormone called estrogen, which causes the uterine lining to increase in thickness. The uterine lining becomes thicker so that the fertilized egg can attach to it.
4. The ovary releases an egg on day 14. Assume that no sperm is present.
5. The egg moves through the oviduct and enters the uterus.
6. Meanwhile the uterine lining continues to thicken.
7. The egg has not been fertilized, therefore, it will not attach to the uterus.
8. The thick uterine lining is no longer necessary, so the cells of the thickened uterine lining break off and leave the vagina. The unfertilized egg is lost and some blood is lost too. This loss of cells from the uterine lining, blood, and egg is called menstruation.
9. After menstruation, the cycle starts again.

Did you know that menstrual cramps are the results of the strong contractions of the uterine wall that occur before and during menstruation? The cramps can be caused by excessive secretion of prostaglandins. Shedding of the endometrium of the uterus results in the inflammation in the endometrial layer of the uterus and prostaglandins are produced as a consequence of the inflammation.

As you perform Activity 6, you'll be able to understand the feedback mechanisms in the female reproductive system.

Activity 6

Mark My Calendar!

Objective:

Describe the feedback mechanisms involved in regulating processes in the female reproductive system

Materials:

- 2 calendar charts
- diagrams of the male and female reproductive system
- scissors
- tape or glue

Procedure:

Part A - For no fertilization:

1. Get a calendar, with an approximate size of 8 x 11 inches. It must be marked by the day-to-day changes in the menstrual cycle.
2. Note that certain events are marked on certain days.

3. Make a copy of the diagrams of the menstrual cycle like in Figure 12. Some of the diagrams will show events in the ovary, and some will show events in the uterus. They are not in proper order. Cut out each square.

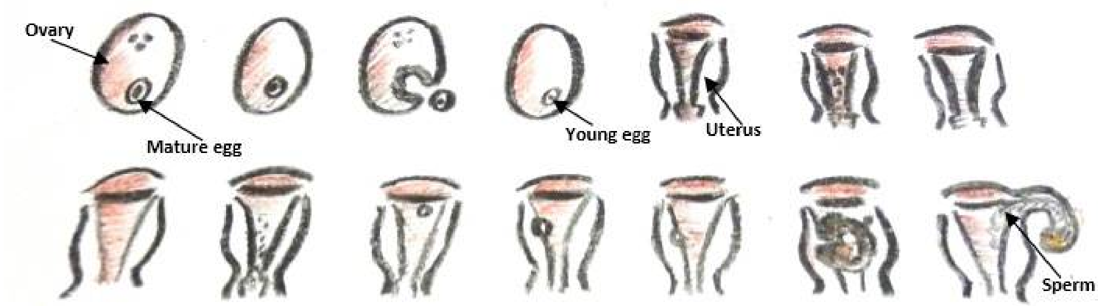


Figure 12. Unsequenced events in the menstrual cycle

4. Place the diagram in the space to the right of the corresponding description.
5. Tape or glue your diagrams in right places/dates where they occur.
6. Make sure that they are correctly placed.

Part B – With fertilization of the egg

1. Get another calendar marked by the day-to-day changes in the menstrual cycle.
2. You will be given a set of diagrams to place on the calendar. The diagrams will not be in proper order. You may not need all the diagrams that show the uterus.

Guide Questions:

Q30. How long does a regular menstrual cycle last?

Q31. Describe what happens to an egg during the first 14 days of the cycle in Part A.

Q32. Describe what happens to the egg if fertilization occurs.

Q33. Explain what takes place in the uterus after fertilization.

Q34. Why is it important to study the menstrual cycle?

A feedback mechanism is the process through which the level of one substance influences the level of another substance. A negative feedback affects the production of hormones in the menstrual cycle. High levels of one hormone may inhibit the production of another hormone.

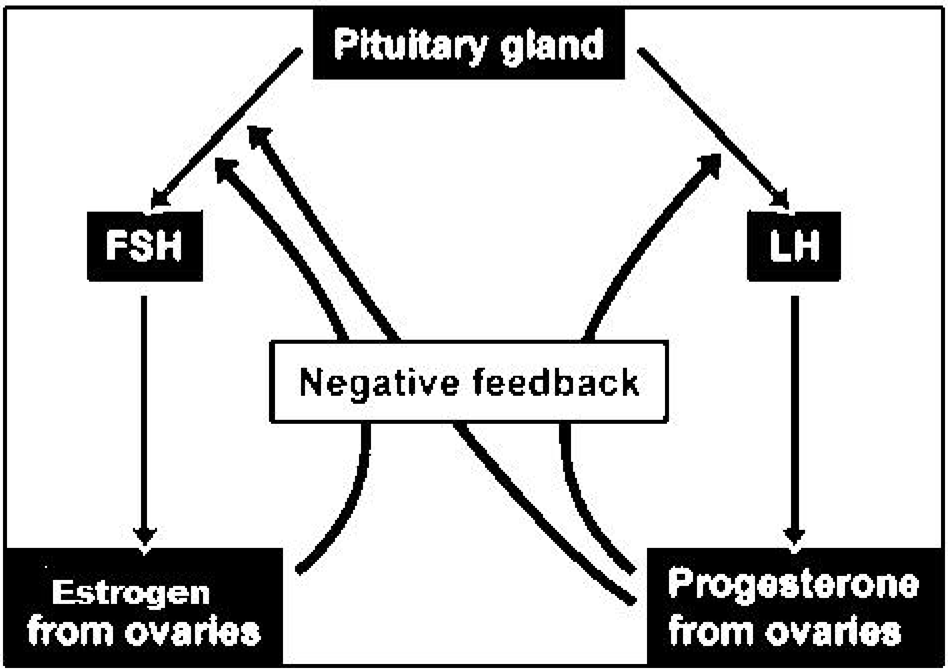


Figure 13. Negative feedback mechanisms in the menstrual cycle

Feedback mechanisms in menstrual cycle:

1. Follicle stimulating hormone (FSH) stimulates the ovaries to release estrogen. High levels of estrogen then prevent the further production of FSH.

2. Estrogen also stimulates the release of luteinizing hormone (LH) from the pituitary gland, which in turn controls the production of progesterone. High levels of progesterone then inhibit the further release of LH.

Nervous System Working Together with Endocrine System to Maintain Homeostasis

Both the nervous system and endocrine system are important in enabling the body to maintain homeostasis. **Homeostasis** is the state reached when each part of the body functions in equilibrium with other parts. This is attained through the regulation of the bodily functions by the endocrine and nervous systems.

Most body systems maintain homeostasis by using feedback mechanisms. When the brain receives messages from the body about an internal change in one of its systems, it works to restore the system to its normal state. The levels of hormones in the body are controlled by feedback. It is important that the amount of hormones in our body is kept at the right level. The endocrine system plays an important part in homeostasis. To achieve homeostasis, the nervous and endocrine systems maintain a normal range of the following variables:

- Body temperature
- Amount of water in the body
- Amount of metabolic wastes in the cell
- Blood calcium level
- Hormones in the blood

Q35. What might happen to a person whose nervous and endocrine systems fail to maintain homeostasis?

Q36. Suppose a boy skipped his lunch for the day. How will the hormones (glucagon) from his pancreas help his body to cope when his blood sugar level drops below normal?

Q37. Suppose a girl ate too many sweets such as candies and chocolates. How will the hormones (insulin) from her pancreas help her body cope with a possible blood sugar level rise above normal?

Q38. How do the nervous and endocrine systems respond to an increase in environmental temperature to achieve homeostasis?

Q39. How do the nervous, endocrine, and reproductive systems perform their coordinated functions in various functions such as pregnancy and childbirth, menstrual cycle, breastfeeding, and sexual intercourse?

Performance Task: Video Making

Topic: Contraceptive Measures

Goal: Your objective is to present information to the public about the common and effective contraceptive measures used in family planning, in line with the Reproductive Health Law. The video that you will create must be in persuasive form. The challenge is how you will be able to convince people about the benefits of various contraceptive measures using gathered facts and scientific evidences.

Role: Assume the role of a professional video production team. You are tasked to produce a promotional video that will be used in campaign advertising about various contraceptive measures used in family planning.

Audience: Your voice, as part of the youth, will be heard through your campaign advertising. You will present the finished video in front of your class. After that, you may also opt to use social media advertising to let other people view your multimedia presentation. It is important to clearly communicate your purpose from the beginning of the video.

Situation: Campaign advertising is often accomplished by combining a short message with a catchy tune that people are likely to remember. Since one of the most powerful means of communicating information today is through music, you may persuasively share your thoughts and ideas on the topic using a chosen melody. After studying the coordinated functions of the reproductive, endocrine, and nervous systems, you will be able to use scientific and logical explanations in promoting various contraceptive measures. There are challenges to overcome in accomplishing the task such as the conflicting judgments of people on the issue that may cause various controversies. Therefore, it is important to be objective in presenting ideas rather than being subjective.

Product/Performance: Produce a campaign advertising video that presents common and effective contraceptive measures used in family planning. The maximum video duration is three (3) minutes. You may seek assistance from your teacher in MAPEH regarding the tune, rhythm and beats of the music. For the rhyme and wordplay to be used, you may consult your teacher in English.

Standards: You will be given two (2) days to conceptualize and execute your ideas through video-making. Once the video is finished, you may already present it in front of the class for evaluation. Your multimedia presentation will be assessed according to the rubric that will be given to you by your teacher.

V. Summary/Synthesis/Feedback

- The nervous system is composed of cells, tissues, and organs that regulate the body's responses to internal and external stimuli. Each component of the nervous system has a specific role to do as an important part of a team.
- The nervous system has two main divisions, which are the Central Nervous System (CNS) and the Peripheral Nervous System (PNS).
- The Central Nervous System (CNS) serves as the main "processing center" for the entire nervous system. It has two main parts, which are the brain, and the spinal cord.
- The Peripheral Nervous System (PNS) contains all nerves that extend outside the brain and spinal cord. It has two main divisions, which are the Somatic Nervous System and the Autonomic Nervous System.
- The basic unit of the nervous system is the nerve cell. Nerve cells are called neurons. Neurons have dendrites and axons that aid in transmitting message.
- Neurons have the special ability to carry signals or impulses. A nerve impulse is an electrochemical gradient moving along a neuron. The space between neurons is called synapse. A stimulus is any factor in the environment that may induce a nerve impulse that initiates physiological and behavioural changes. A response is a reaction to a condition or stimulus. To survive, an organism must be able to respond to a stimulus. Reaction time is the length of time between application of a stimulus and detection of a response.
- When a receptor such as an organ perceives a stimulus, the impulse is sent to the brain by the sensory neurons, transmitting information from one nerve cell to another. As the message reaches the brain, it processes the information and commands an effector such as a muscle or an organ to respond. The message coming from the brain is sent through the motor neurons.
- The Endocrine System consists of glands that secrete chemicals called hormones which control various body processes. This control system usually brings about slow changes in the body because chemical messengers move more slowly than nerve impulses. The major glands in the body are the pituitary, thyroid, parathyroid, thymus, adrenal, pancreas, ovaries and testis.

- Hormones affect various processes in the body as they regulate and balance the functioning of organs, tissues, and cells. Hormones greatly influence growth, appearance, emotions, and reproductive functions. These chemicals play an essential role in the occurrence of disorders such as diabetes, thyroid disease, growth and/or sexual dysfunction. Hormones act in very small amounts. An increase or decrease in the said amount may result in a body disorder due to hormonal imbalance.

- The Reproductive System is a collection of organs in an organism that function together for sexual reproduction. The male reproductive organs are the penis, the testicles, the epididymis, the vas deferens, and the prostate gland. The female reproductive organs are the vagina, uterus (womb), Fallopian tubes, and ovaries.

- Hormones play an important role in both male and female reproductive systems. The pituitary gland controls the functions of both the testes and the ovaries. These hormones keep the reproductive system properly functioning.

- Hormones secreted by the ovaries and a small gland in the brain called the pituitary gland control the menstrual cycle.

- Feedback mechanism is the process through which the level of one substance influences the level of another substance. A negative feedback affects the production of hormones in the menstrual cycle. High levels of one hormone may inhibit the production of another hormone.

- Homeostasis is the state reached when each part of the body functions in equilibrium with other parts. This is attained through the regulation of the bodily functions by the endocrine and nervous systems.

VI. Summative Assessment

I. Answer briefly the following questions. (2 pts. each)

1. How does the Central Nervous System (CNS) function similarly to the Central Processing Unit (CPU) of a computer?
   ____
2. Why are there significant changes in the body at puberty stage?
   ____
3. In what way do the nervous and endocrine systems differ in the way they communicate messages throughout the body?
   ____
4. Why is it important to maintain homeostasis in the body?
   ____

II. Match each gland in column A with its corresponding function in column B. (1 pt. each)

A	B
a. Stimulates growth, and controls the functions of other glands	1. Thymus
b. Controls the calcium levels in your body, and normalizes bone growth	2. Pancreas
c. Regulates body metabolism, and causes storage of calcium in bones	3. Adrenal
d. Enables the body to produce certain antibodies	4. Thyroid
e. Prepares the body for action, and controls the heart rate and breathing in times of emergency	5. Parathyroid
f. Controls maturation and male characteristics	6. Pituitary
g. Regulates blood sugar levels	
	7. Testis
h. Influence female traits and support reproductive function	8. Ovaries

III. Draw and label the parts of a neuron. (4 pts.)

Glossary of Terms

Axon the part of the neuron that transmits impulses away from the cell body

Dendrite the branchlike structure of the neuron that extends from the cell body to receive an impulse

Embryo an organism in its early stages of development, especially before it has reached a distinctively recognizable form

Endocrine Gland an organ that produces chemical secretions released directly into the bloodstream

Egg Cell also called ovum (plural: ova); the female gamete

Fertilization a process that occurs when the sperm and egg combine to produce an embryo

Homeostasis the ability or tendency of an organism to maintain internal equilibrium by regulating its processes

Hormone a chemical substance produced in the body that controls and regulates the activity of certain cells or organs

Impulse an electrochemical gradient moving along a neuron

Neuron the basic unit of the nervous system, also called nerve cell, that transmits messages to and from the central nervous system

Semen the ejaculated fluid containing sperm cells and secretions from the seminal vesicle, prostate gland, and bulbourethral gland

Sperm shorter term for spermatozoon (plural: spermatozoa); the male gamete

Stimulus any factor in the environment that influences the behavior of an organism

Synapse the space between neurons where electrochemical signals pass

References and Links

Printed Materials:

Rabago, L., et al (2010). *Functional Biology - Modular Approach*. 2nd ed. Philippines: Vibal Publishing House, Inc

Strauss, E; Lisowski, M. (2003). *Biology: The Web of Life*. 2nd ed. Philippines: Pearson Education Asia Pte Ltd..

(DepEd Materials)
BEAM: Biology – Organ System – Endocrine and Nervous Systems
EASE, Module 9: Life Support Systems
EASE, Module 13: Reproductive Systems
APEX Biology – Unit IV, The Organ Systems

Electronic Sources:

ADAM Inc. (2013). Central Nervous System. Retrieved July 5, 2014 from: http://www.nlm.nih.gov/medlineplus/ency/article/002311.htm

Alzeimer's Association (2011). Three Main Parts of the Brain. Retrieved July 4, 2014 from:https://www.alz.org/braintour/3_main_parts.asp

Encyclopedia Britannica Inc. (2014). Homeostasis. Retrieved July 5, 2014 from: http://global.britannica.com/EBchecked/topic/270188/homeostasis

KG Investments (2014). Stimulation Crucial to Devt. Retrieved July 3, 2014 from: http://www.kidsgrowth.com/resources/articledetail.cfm?id=259

MCB Berkely (2014). The Central Nervous System. Retrieved July 4, 2014 from: http://mcb.berkeley.edu/courses/mcb135e/central.html

Missouri University of Science and Technology (n.d.). Neuroscience. Retrieved July 5, 2014 from: http://web.mst.edu/~rhall/neuroscience/02_structure_and_pharmacology.pdf

National Center for Infants (2014). Zero to Three. Retrieved July 5, 2014 from: http://www.zerotothree.org/child-development/brain-development/

Public Library of Science (2004). A Window into the Brain. Retrieved July 4, 2014 from: http://www.plosbiology.org/article/info:doi/10.1371/journal.pbio.0020115

Tamarkin, Dawn (2011). The Nervous System. Retrieved July 4, 2014 from: http://faculty.stcc.edu/AandP/AP/AP1pages/nervssys/unit10/division.htm

University of Texas (2012). Health Science. Retrieved July 3, 2014 from: http://teachhealthk-12.uthscsa.edu/ curriculum/ brain/brain01e-Wires.asp

http://www.animalintelligence.org/2006/08/04/duck-and-chicken-raise-family-together/

Unit 3
MODULE
2

Suggested Time Allotment: 8 hrs.

HEREDITY: INHERITANCE and VARIATION

I. Introduction

You learned in Grade 9 that many genes in plants and animals behave differently than the genes that Mendel studied in peas, where traits are not entirely controlled by dominant and recessive genes. You also learned how the genes in your deoxyribonucleic acid (DNA) influence your characteristics.

Now, you will work on activities to assess your understanding on the structure of the DNA, explain how DNA replication takes place, how ribonucleic acid (RNA) is made using the information from DNA, how information in some genes is translated into proteins, and explain how mutations may cause changes in the structure and function of a protein.

Many investigations of how the genes control cells were done even before scientists first knew that genes were made of DNA. The American geneticists George Beadle and Edward Tatum established the connection between genes and enzymes. The experiments of Beadle and Tatum linked genes to actual products of cells and showed the importance of genes to cellular activity. In other words, a gene is a portion of DNA that contains the instructions for the synthesis of specific RNA or protein.

Building a house usually requires a blueprint, or a plan of the structure of the house to determine how it would look like after construction. Organisms have blueprints which contain information that will determine their physical and chemical characteristics. This blueprint is DNA.

II. Learning Competencies/Objectives

In this module, you are expected to:
1. explain how a protein is made using information from DNA.
    a. identify the role of DNA and RNA in protein synthesis
    b. describe DNA replication
    c. relate DNA replication to its complementary structure
    d. describe transcription and translation.

2. Explain how mutations may cause changes in the structure and function of a protein.
    a. Compare the different types of mutations and their possible results.

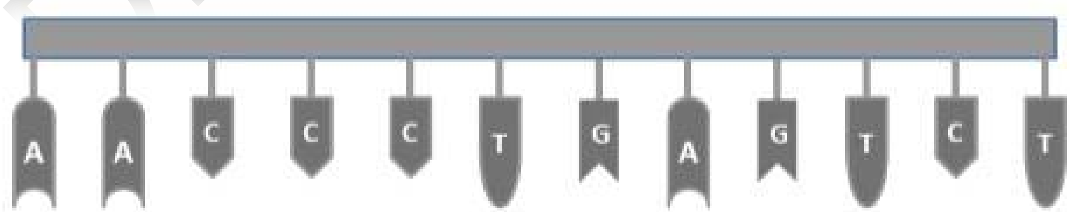
Answer the following questions as you work on the activities in this module.

Key questions for this module:

1. How is DNA made out of a DNA template?
2. How is RNA made out of a DNA template?
3. How is protein made out of a RNA template?
4. How does mutation result to change in the structure and function of a protein?

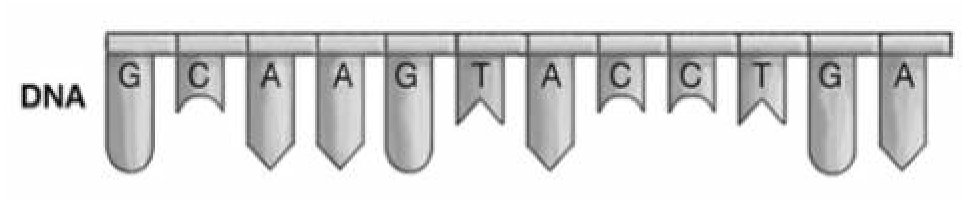
III. Pre-Assessment

Directions: Answer the following questions:
1. The sequence of bases in one DNA strand is given below. Identify the complementary sequence of bases in the other strand of DNA.



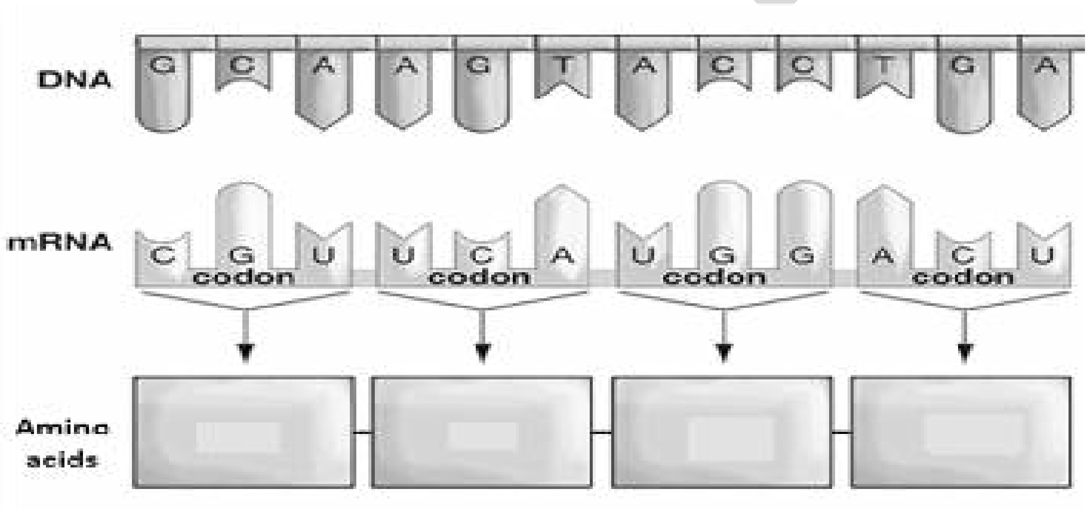
____

2. Show how the DNA code translates into RNA code by placing the sequence of bases of the DNA and RNA side by side.



RNA ______________________________

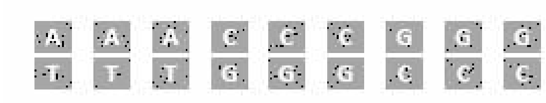
3. Each combination of three nitrogenous bases on the mRNA molecule is a codon, a three letter code for a specific amino acid. Use the table below to identify the specific amino acid for each mRNA codon.



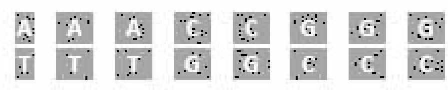
THE GENETIC CODE

First letter	Second letter: U		Second letter: C		Second letter: A		Second letter: G		Third letter
U	UUU UUC	Phenyl-alanine	UCU UCC UCA UCG	Serine	UAU UAC	Tyrosine	UGU UGC	Cysteine	U C
	UUA UUG	Leucine			UAA UAG	Stop codon Stop codon	UGA	Stop codon	A
							UGG	Tryptophan	G
C	CUU CUC CUA CUG	Leucine	CCU CCC CCA CCG	Proline	CAU CAC	Histidine	CGU CGC CGA CGG	Arginine	U C
					CAA CAG	Glutamine			A G
A	AUU AUC AUA	Isoleucine	ACU ACC ACA ACG	Threonine	AAU AAC	Asparagine	AGU AGC	Serine	U C
	AUG	Methionine; initiation codon			AAA AAG	Lysine	AGA AGG	Arginine	A G
G	GUU GUC GUA GUG	Valine	GCU GCC GCA GCG	Alanine	GAU GAC	Aspartic acid	GGU GGC GGA GGG	Glycine	U C
					GAA GAG	Glutamic acid			A G

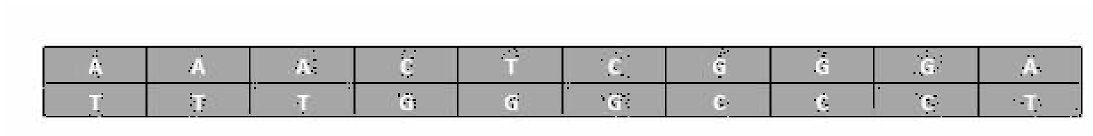
4. Look at the four DNA sequences of bases below.



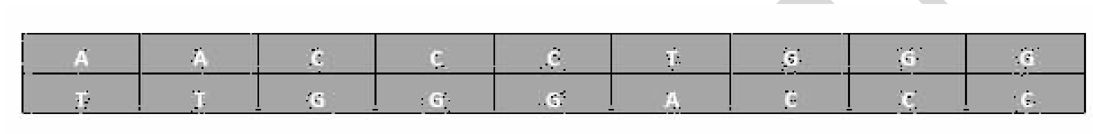
Original sequence



Base pair removed



Base pair replaced



Base pair replaced

How does each of these errors change the DNA sequence? What do you call these changes? ____

Now, you will work on the initial assessment activity to measure your understanding of DNA and RNA structures.

IV. Reading Resources and Instructional Activities

Activity 1

Getting to Know the DNA and RNA Structure

Objective:

Compare the structures of the DNA and RNA molecule

Material:

Activity sheets

Procedure:

1. Read the given information carefully about DNA and RNA.

Component molecules

1. The DNA molecule is composed of three types of component molecule: phosphate group, the sugar deoxyribose, and the bases adenine, thymine, cytosine, guanine (A, T, C, G).

Nucleotides

2. There are three molecules that form the basic building block of DNA, the nucleotides. Each nucleotide is composed of one phosphate group, one sugar molecule, and one of the four bases – in the example. Across the strands of the helix, A always pairs with T, and G with C.

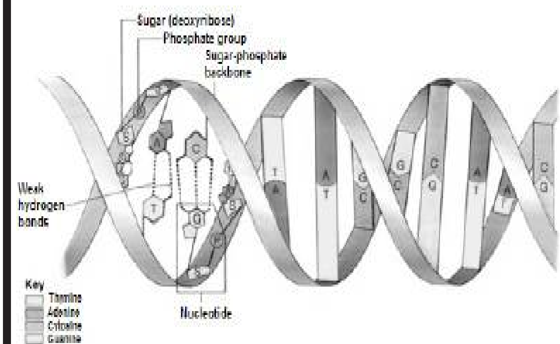


Figure 1. DNA Structure

Ribonucleic Acid, like DNA, is a nucleic acid. However, RNA structure differs from DNA structure in three ways, shown in Figure 2. First, RNA is single stranded – whereas DNA is double stranded. Second, the sugar in RNA is ribose; DNA has deoxyribose. Finally, both DNA and RNA contain four nitrogenous bases, but instead of thymine, RNA contains a similar base called uracil (U). The uracil pairs with adenine. The major types of RNA include: messenger RNA (mRNA), ribosomal RNA (rRNA), and transfer RNA (tRNA).

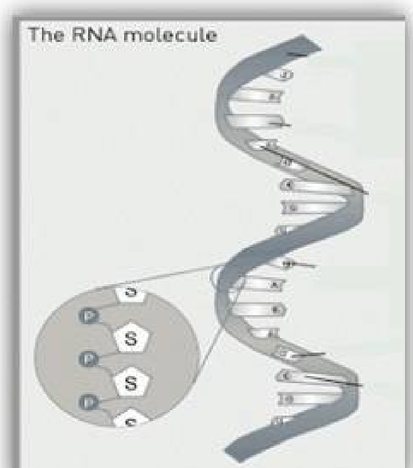


Figure 2. RNA Structure

2. Fill in the comparison table below.

Basis of Comparison	DNA	RNA
1. Number of strands		
2. Location in the cell		
3. Type of sugar		
4. Nitrogenous base pair		

Guide Questions:
Q1. What are the components of the DNA and RNA molecule?

Q2. What is the structural difference between DNA and RNA?

Q3. What nitrogenous base is found in RNA but not in DNA?

KEY CONCEPTS:
- A DNA is a double helix molecule composed of complementary strands of deoxyribonucleotides units. The complementary base pairs of the DNA are held by hydrogen bonds.
- RNA is single stranded.
- Examples of RNA types include: mRNA, rRNA and tRNA.
- In DNA, adenine always bonds with thymine, and cytosine bonds with guanine. In RNA, adenine bonds with uracil, and cytosine bonds with guanine.

Replication

In 1953, James Watson and Francis Crick worked out that DNA is double helix like a twisted staircase. The two sugar-phosphate backbones make up the sides and the base pairs make up the rungs or steps of the twisted staircase.

Deoxyribonucleic acid is copied during interphase prior to mitosis and meiosis. It is important that new copies are exactly like the original molecule. The structure of the DNA provides a mechanism for making accurate copies of the molecule. The process of making copies of DNA is called replication. When DNA replicates, two identical copies of DNA molecules are produced, which are exactly the same as the original.

The central dogma of the transfer of genetic information is outlined below.

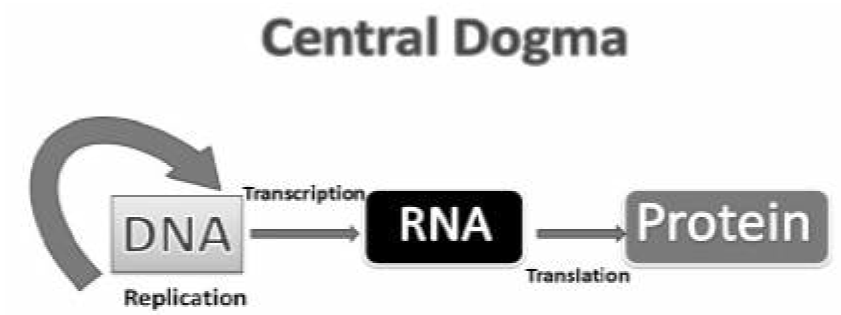


Figure 3. Transfer of genetic information

You will work on the next activity to demonstrate the replication of the DNA molecule and the specificity of base pairing in the nitrogenous bases.

Activity 2

DNA Makes DNA

Objective:

- Make a model of a DNA template to determine the sequence of bases in the new DNA strand.

Materials:

- crayons
- scissors
- paste/tape
- 1/4 size illustration board or long size folder

Procedure:

1. Use the patterns of the components of the DNA provided by your teacher. Color code phosphate = blue, deoxyribose sugar = green and nitrogenous bases as follows: adenine = yellow, thymine = pink, guanine = violet and cytosine = red.

2. Cut out the shapes of each nucleotide.

3. Build a model of a strand of a DNA molecule. The strand should contain 6 base "rungs" following the given order of the nucleotides below.
   Guanine
   Adenine
   Cytosine
   Thymine
   Cytosine
   Guanine

4. Tape the cut out pattern to form the nucleotides.

5. Let this arrangement represent the left half of your DNA molecule.

6. Make a complementary strand for the first strand that you made in step 3.

7. Tape the cut-out pattern forming nucleotides for the second strand of the DNA molecule.

8. Match the bases of the first strand and the second strand. Do not tape across bases.

9. Once you have made your DNA model, separate the two strands of the DNA model down the middle so that there are now two single strands of DNA.

10. Create new double-stranded DNA by matching complementary nucleotides to the bases on each single strand.

11. Tape and then cut out the pattern forming the nucleotides for each of the single nucleotides.

12. When you are finished, mount the original DNA model and the DNA model with its complementary strand in the illustration board or folder.

Guide Questions:

Q4. Compare the two new strands of DNA. Are they the same or different? Why?

Q5. How do the nucleotides in DNA pair?

Q6. How do you compare a DNA molecule to a zipper?

Q7. How is information from the DNA passed on from one cell to another?

Q8. How does the structure of a DNA molecule help account for the great variety of life that exists on earth?

Do you understand the process by which DNA copies itself? The following are the events while DNA copies itself:

- Step 1. An enzyme called helicase breaks the bond between nitrogenous bases. The two strands of DNA split.

- Step 2. The bases attached to each strand then pair up with the free nucleotides found in the cytoplasm.

- Step 3. The complementary nucleotides are added to each strand by DNA polymerase to form new strands. Two new DNA molecules, each with a parent strand and each with a new strand are formed. The DNA replication is known as semi-conservative replication, because one of the old strands is conserved in each new molecule. Figure 4 illustrates the semi-conservative replication of DNA.

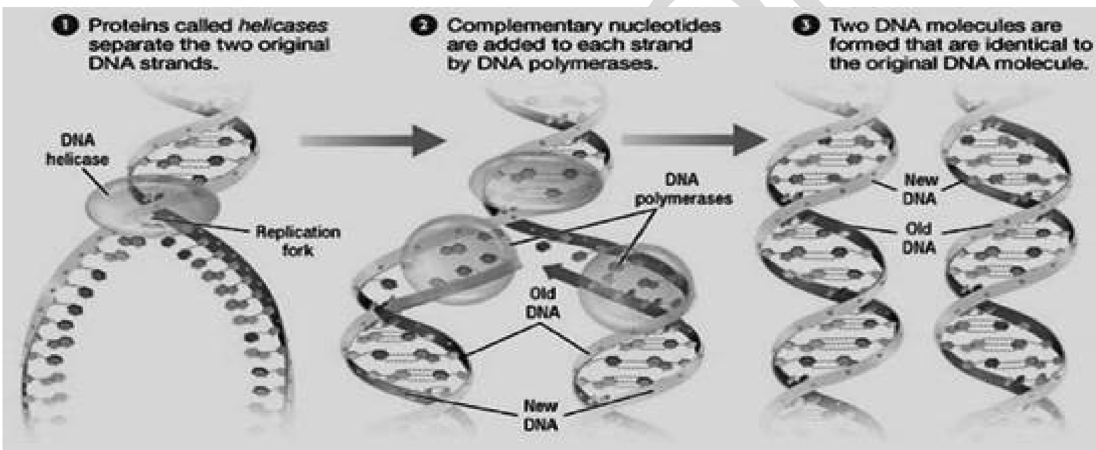


Figure 4. DNA Replication

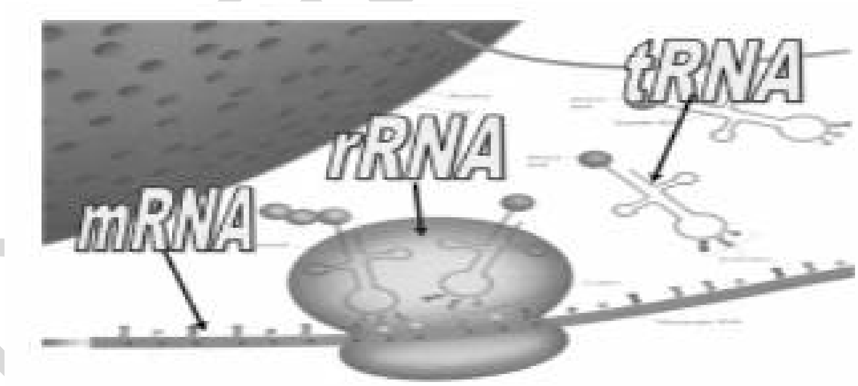
KEY CONCEPTS:
- DNA is made up of sugars, phosphate groups, and nitrogenous bases and its shape is a double helix. The complementary structure the two strands of DNA allow each strand to serve as a template during replication.
- The specificity of base pairing in DNA, adenine with thymine, and cytosine with guanine, allows DNA to replicate itself with accuracy.

What do you think is the role of RNA in making proteins in the cell? Can you imagine a car being assembled in a car factory? By way of analogy, different cars are being built in many simple steps. Engineers tell workers how to make cars, and the workers follow directions to build the cars. Suppliers bring parts to the factory so they can be installed in the car. Protein production is similar to car production. It is the role of the DNA to provide workers with the instructions for making the proteins, and the workers build the proteins. Other workers known as amino acids, bring parts to the factory. RNA molecules or the workers for protein synthesis get the instructions from the DNA on how the protein should be assembled.

Moreover, do you know that there are three types of RNA that help build proteins? You can consider these RNA molecules to be the workers in the production of protein.

- One type of RNA, messenger RNA (mRNA) brings information from the DNA in the nucleus to the protein manufacturing area, the cytoplasm. In the cytoplasm, the mRNA becomes the template of information to make proteins.

- Ribosomes, made of ribosomal RNA (rRNA), and ribosomal proteins hold tightly into the mRNA using its information to assemble the amino acids in correct order.



Source: internalcampaignschools.org
Figure 5. Types of RNA

- Transfer RNA (tRNA) supplies amino acids to the ribosome to be assembled as protein.

Did you find this car-making analogy helpful? But, how does the information in DNA, which is found in the nucleus, move to the ribosome in the cytoplasm?

TRANSCRIPTION

In the next activity, you will demonstrate the process of transcription through the use of paper DNA and mRNA models.

Activity 3

What's the Message

Objectives:

- Make a model to show how the order of bases in DNA determines the order of bases in mRNA.
- Infer why the structure of DNA enables it to be easily copied.

Materials:

- crayons
- 1/4 illustration board or long folder
- scissors
- paste/tape

Procedure:

1. Use the patterns of the components of the DNA provided by your teacher. Color code phosphate = blue, deoxyribose sugar = green, ribose sugar = brown and nitrogenous bases as follows: adenine = yellow, thymine = pink, guanine = violet and cytosine = red and uracil = orange.

2. Cut out the shapes of each nucleotide.

3. Using the given order of the nucleotides below, construct a double stranded DNA molecule.

   Guanine
   Adenine
   Cytosine
   Thymine
   Cytosine
   Guanine

4. Fasten your molecule together using a clear tape. Do not tape across base pairs.

5. Step 1, use the patterns of the components of the RNA provided by your teacher. Color code phosphate = blue, ribose sugar = brown and nitrogenous bases as follows: adenine = yellow, uracil = orange, guanine = violet and cytosine = red.

6. Cut out the shapes of each nucleotide.

7. With your DNA model in front of you, demonstrate the process of transcription by first pulling the DNA model apart between the base pairs.

8. Using the right strand of the DNA model in step 3, begin matching complementary RNA nucleotides with the exposed bases on the DNA model to make mRNA.

9. Tape the RNA nucleotides.

10. When you are finished, tape your new mRNA molecule together.

Q1. Does the mRNA model more closely resemble the DNA strand from which it was transcribed?

Q2. Explain how the structure of DNA enables the molecule to be easily transcribed. Why is this important for genetic information?

Q3. Why is RNA important to the cell?

Q4. How does a mRNA molecule carry information from DNA?

Do you know how the information in DNA, which is found in the nucleus, move to the ribosome in the cytoplasm? The following events can help you understand the process of transcription:

- Step 1. Ribonucleic Acid polymerase enzyme binds and opens the DNA molecule that will be transcribed.
- Step 2. As the DNA molecule opens, the RNA polymerase slides along the DNA strand and links free RNA nucleotides that pair with the nitrogenous bases of the complementary DNA strand. Hence, if the sequence of bases on the DNA strand were CCG TTA CAT, the sequence of bases on the RNA strand would be GGC AAU GUA.
- Step 3. When the process of base-pairing is completed, the RNA molecule breaks away as the DNA strands rejoin. The RNA leaves the nucleus and goes to the cytoplasm. Figure 6 shows the transcription process.

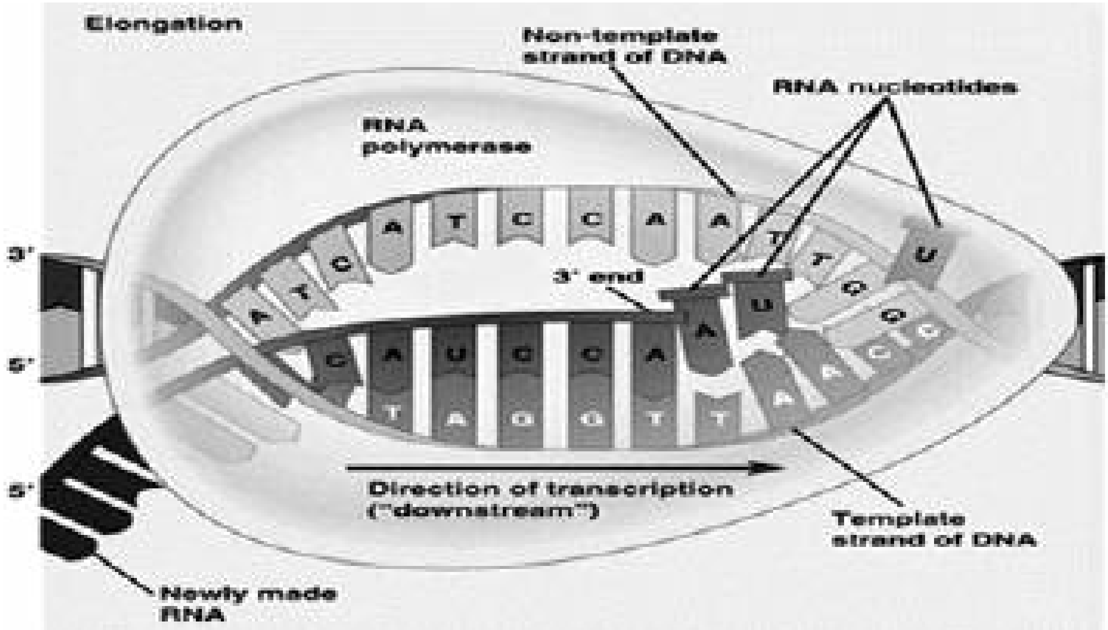


Figure 6. Transcription

KEY CONCEPTS:
- The sequence of nucleotides in DNA directs the order of nucleotides in messenger RNA in a process called transcription.
- There are three major types of RNA that help build proteins: mRNA, rRNA, and tRNA.
- The mRNA carries the information in DNA to the ribosomes found in the cytoplasm.

TRANSLATION

The DNA directs the production of proteins and determines the formation of mRNA. The order of bases of mRNA determines the protein synthesized.

Proteins control the activities of the cell, as well as so the life of the entire organism. But how does DNA make a unique protein that will perform a special function? Would you like to find out how the message of the mRNA is translated to proteins?

Work on the next activity to demonstrate the process of translation.

Activity 4

Relay the Message

Objectives:

- Make a model of the translation process
- Simulate the steps in translation

Materials:

- crayons
- 1/4 size illustration board or long size folder
- scissors
- paste/tape

Procedure:

1. Use the patterns of the components of the DNA and RNA provided by your teacher. Color code phosphate = blue, deoxyribose sugar = green ,ribose sugar = brown and nitrogenous bases as follows: adenine = yellow, uracil = orange, guanine = violet, cytosine = red and amino acid = green.

2. Cut out the shapes of each nucleotide.

3. Using the given order of the nucleotides below, construct a double stranded DNA molecule.

   Guanine
   Adenine
   Cytosine
   Thymine
   Cytosine
   Guanine

4. Fasten your molecule together using a clear tape. Do not tape across base pairs.

5. Step 1, use the patterns of the components of the RNA provided by your teacher. Color code phosphate = blue, ribose sugar = brown and nitrogenous bases as follows: adenine = yellow, uracil = orange, guanine = violet and cytosine = red.

6. Cut out the shapes of each nucleotide of RNA.

7. With your DNA model in front of you, pull apart the DNA model.

8. Using the right strand of the DNA model in step 3, begin matching complementary RNA nucleotides with the exposed bases on the DNA model to make mRNA.

9. Tape the RNA nucleotides.

10. Fasten your molecule together using a clear tape. Imagine that mRNA leaves the cell nucleus and moves out to the cell's ribosomes. Meanwhile, transfer RNA (tRNA) is present in the cell cytoplasm. tRNA has a three –base sequence (a triplet) that can match with the bases of mRNA.

11. Cut out the two models of tRNA only along solid lines.

12. Join the tRNA molecules to the mRNA model.

13. When you are finished, tape your model of the translation process on the illustration board or folder.

Q13. What are the four nucleotide bases present in tRNA? Do these bases differ from those found in mRNA?

Q14. What base in mRNA can only join with the adenine base of RNA? uracil base of tRNA?

Q15. What is a codon? What does it represent?

Q16. What is the role of tRNA in protein synthesis?

Q17. How does a tRNA molecule carrying its amino acid recognize which codon to attach?

Q18. You have learned that there is a stop codon that signals the end of an amino acid chain. Why is it important that a stop codon be part of protein synthesis?

Q19. A construction worker brings hollow blocks to build a wall. What part of translation resembles the construction worker's job? What do the hollow blocks represent?

In translation, each set of three nucleotides in an mRNA molecule codes for one amino acid in a protein. This explains why each set of three nucleotides in the mRNA is called a codon. Each codon specifies a particular amino acid. For example, the first codon which is, cytosine-guanine-uracil (CGU), instructs the ribosome to put the amino acid arg (arginine) in the protein. The sequence of codons in the mRNA determines the sequence of amino acids in the protein.

But how are the right amino acids added in the right sequence to match the sequence of codons in the mRNA? The following events in translation can help you understand the process:

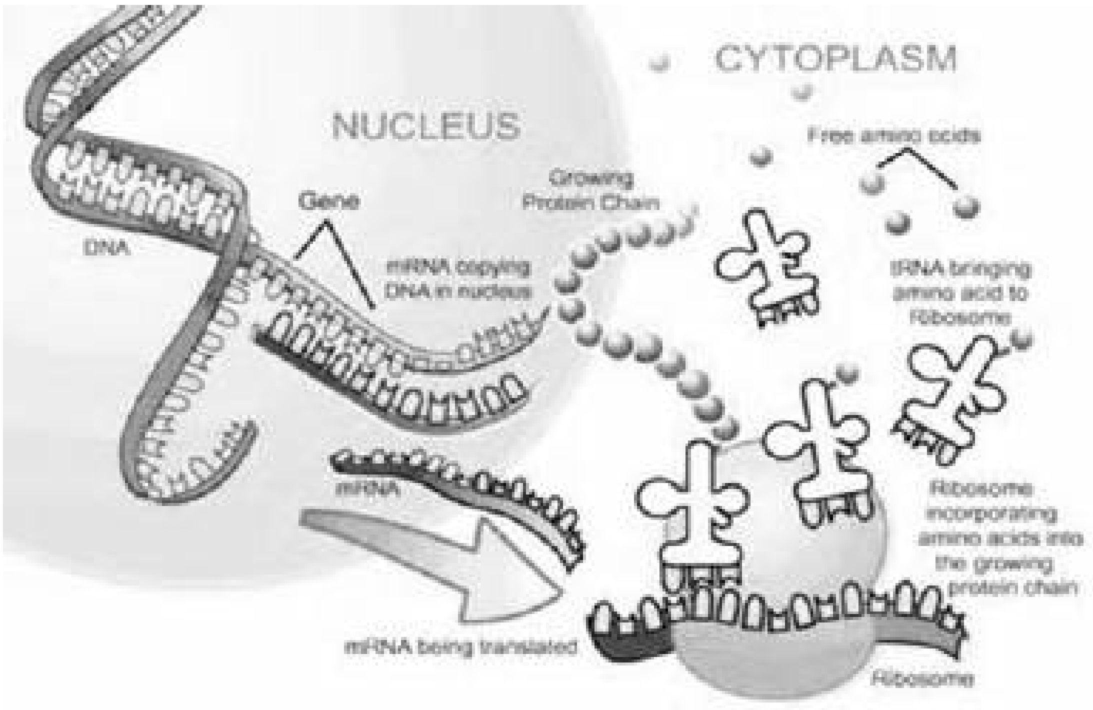
- Step 1. As translation begins, mRNA binds to a ribosome. Then, tRNA molecules, each carrying a specific amino acid, approach the ribosome. The tRNA anticodon pairs with the first mRNA (start) codon argenine-uracil-guanine (AUG), to form the initiation complex. The two molecules temporarily join together.

- Step 2. Usually, the first codon on mRNA is AUG, which codes for the amino acid methionine. AUG signals the start of protein synthesis. Then, the ribosome slides along the mRNA to the next codon.

- Step 3. A new tRNA molecule carrying an amino acid pairs with the second mRNA codon.

- Step 4. When the first and second amino acids are in place, an enzyme joins them by forming a peptide bond between them.

- Step 5. As the process continues, a chain of amino acids is formed until the ribosome reaches a stop codon (e.g., UAA,UAG,UGA) on the mRNA strand. The polypeptide chain is released. Protein synthesis is complete. Figure 7 summarizes the translation process.



Source: www.scq.ubc.ca
Figure 7. Translation

KEY CONCEPTS:

- The process of converting the information in messenger RNA into a sequence of amino acids that make a protein is known as translation.
- The role of transfer RNA (tRNA) is to bring the amino acids in the cytoplasm to the ribosomes to make proteins.

Proteins such as enzymes are mostly amino acids chained together in a certain order. Each group of three nucleotide bases represents a codon in a DNA or mRNA that corresponds to a specific amino acid or a start/stop signal. This code is picked up by the mRNA and is carried from the nucleus to the cytoplasm. The codon has its complement anticodon in tRNA. Each amino acid that will form the protein molecule to be synthesized is determined by the triplet code or codon on the mRNA.

In this activity, you will apply what you have learned about DNA and mRNA, and the use of the information in the Genetic Code Table.

Activity 5

Trace the Code

Objective:

- Identify the amino acids coded for by the mRNA codon using the Genetic Code Table.

Materials:

- Genetic Code Table
- activity sheets

Procedure:

1. Copy and fill in the table.
2. Refer to the Genetic Code Table to identify the amino acid.

Order of bases in DNA	Order of bases in mRNA (codon)	Order of bases in tRNA	Amino Acid Coded into Proteins
TAG	AUC		
CAT			
	GUC		
	CCA		
			Methionine
			Valine
	ACU		
ACA	UGU		
AAA			
GAA	CUU		

3. To determine the order of bases in the first column (DNA), second column (codon), and third column (anticodon), consider the complementary base pairs in DNA: adenine pairs with thymine and guanine pairs with cytosine. While in RNA, adenine pairs with uracil and guanine pairs with cytosine.
4. To identify the amino acid, look at the bases in the mRNA codon, e.g., AUG using the **Genetic Code Table**. Look for the first letter of the mRNA codon on the left side of the genetic code table (A), the second letter of the mRNA on the second letter column (U), and the third letter on the right side column (G). AUG codes for the amino acid -methionine.
5. Do the same with the other codons in the chart.

Genetic Code Table

First letter	Second letter: U	Second letter: C	Second letter: A	Second letter: G	Third letter
U	UUU, UUC: Phenylalanine UUA, UUG: Leucine	UCU, UCC, UCA, UCG: Serine	UAU, UAC: Tyrosine UAA: Stop codon UAG: Stop codon	UGU, UGC: Cysteine UGA: Stop codon UGG: Tryptophan	U C A G
C	CUU, CUC, CUA, CUG: Leucine	CCU, CCC, CCA, CCG: Proline	CAU, CAC: Histidine CAA, CAG: Glutamine	CGU, CGC, CGA, CGG: Arginine	U C A G
A	AUU, AUC, AUA: Isoleucine AUG: Methionine; initiation codon	ACU, ACC, ACA, ACG: Threonine	AAU, AAC: Asparagine AAA, AAG: Lysine	AGU, AGC: Serine AGA, AGG: Arginine	U C A G
G	GUU, GUC, GUA, GUG: Valine	GCU, GCC, GCA, GCG: Alanine	GAU, GAC: Aspartic acid GAA, GAG: Glutamic acid	GGU, GGC, GGA, GGG: Glycine	U C A G

Q20. Why is specific base pairing essential to the processes of transcription and translation?

Q21. How many codon/s codes for one amino acid?

MUTATION: Changes in the Genetic Code

When you copy from the blackboard, sometimes you may make mistakes. In a similar way, mistakes may occur when DNA is replicated. Look at Figure 8 to see some common mistakes in replication. Changes in the DNA sequence may delete such protein or change its structure.

Source: www.shmoop.com
Figure 8. Common Mistakes in Mutation

When the code in a gene is changed, a different message may result. Any change in the sequence of nitrogenous bases in the DNA, any mistake in the transcription of genetic information from DNA to RNA or pairing of the codon and anticodon, may cause changes in the kind, sequence and number of amino acids of proteins synthesized by cells. Changes in the protein structure or level of expression may lead to changes in cellular properties and behavior, as a result, the organism is affected. Changes in the genes can occur for a variety of reasons. Mutation may be induced by factors called mutagens. Mutagens are commonly in the form of toxic chemicals, and harmful radiation. Sometimes, mistakes occur in DNA replication, mitosis, and meiosis. All of these can alter the DNA sequence and length.

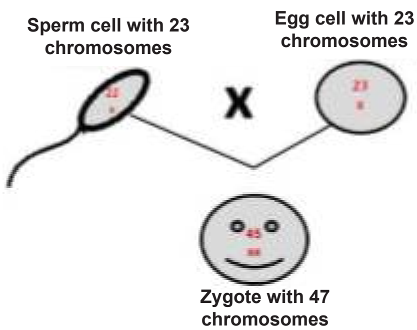


Figure 9. Diagram of a cross with mutated chromosomes

Mutations can occur in two different types of cells: reproductive cells and body cells. Only mutations in sex cells pass on to offspring. Mutations affect the reproductive cells of an organism by changing the sequence of nucleotides within a gene in a sperm or an egg cell. If these cells are fertilized, then the mutated gene becomes a part of the genetic makeup of the offspring as shown in Figure 9. If mutation is severe, the resulting protein may be nonfunctional, and the embryo may not develop. There are two types of mutations that can occur in gamete cells:

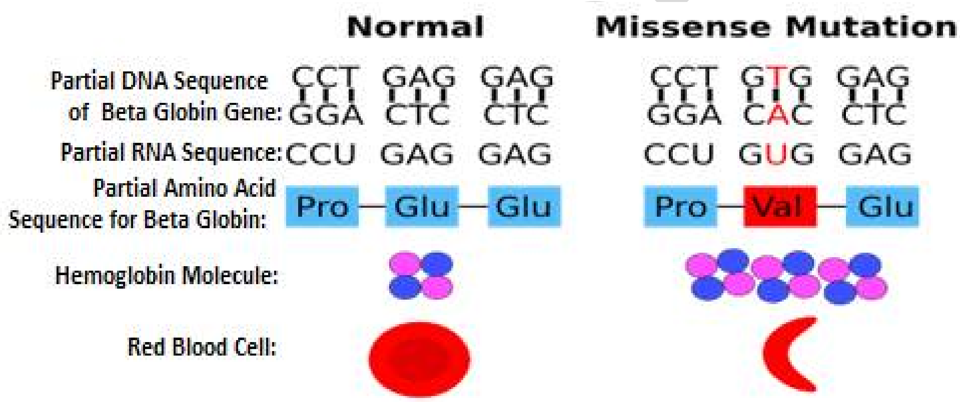
- Gene mutation is a permanent change in the DNA sequence that makes up a gene.
- Chromosomal mutation occurs at the chromosome level resulting in gene deletion, duplication or rearrangement that may occur during the cell cycle and meiosis. It maybe caused by parts of chromosomes breaking off or rejoining incorrectly.

Most mutations are harmful. Some mutations in a body cell are known to cause cancer, while mutations in sex cells can cause birth defects. A severe mutation may lead to cell death and may have no effect on the body. Sometimes mutations may be useful for the species. For example, a mutation in blood proteins prevents viruses or parasites to thrive in host organisms.

- When is mutation inherited? Why are mutations in sex cells heritable?

Many diseases are caused by the effects of inherited genes. In most cases, there is only a small difference between DNA sequences in the defective gene and a normal one. This difference is enough to cause serious and often fatal diseases. These disease-causing genes are the result of a mutation. They may be passed from one generation to the next if present in gametes.

Figure 10 shows changes in the sequences of bases in normal hemoglobin and the one affected by mutation. A recessive gene causes sickle- cell anemia, where most of the red blood cells stiffen and become sickle shape in affected people. These diseased cells carry less oxygen than normal cells. People affected by the disease eventually die.



Source: education-portal.com
Figure 10. Hemoglobin Gene Mutation

Consider what might happen if an incorrect amino acid was inserted in a growing protein chain during the process of translation. Do you think this will affect the structure of the entire molecule? This can possibly happen in point mutation where a change in a single base pair occurs. Read the two sentences below. What happens when a single letter in the first sentence is changed?

THE DOG BIT THE CAT.

THE DOG BIT THE CAR.

Did you see that changing a single letter also changes the meaning of the sentence? A change in nitrogenous base in a protein may yield a different amino acid and a corresponding change in the protein structure and function.

What will happen if a single base is deleted from a DNA strand? You learned in Activity 3 and 4 that an mRNA corresponds to a DNA sequence translated by ribosomes into proteins. If the new sequence with a deleted base was transcribed, then every codon after the deleted base would be different. Deletion or insertion of a base may change the reading frame of the codon leading to frameshift mutation. Read again the two sentences below.

THE DOG BIT THE CAT.

THE DOB ITT HEC AT.

What was deleted? Would the result be the same if there would be an addition of a single base?

Mutations in chromosomes may occur in a variety of ways. Sometimes parts of chromosomes are broken off and lost during mitosis or meiosis.

Now, you will work on an activity that will help you visualize some chromosomal mutations using models.

Activity 6

Chromie Change

Objective:

- Illustrate the kinds of chromosomal mutations
- Differentiate the kinds of chromosomal mutations

Material:

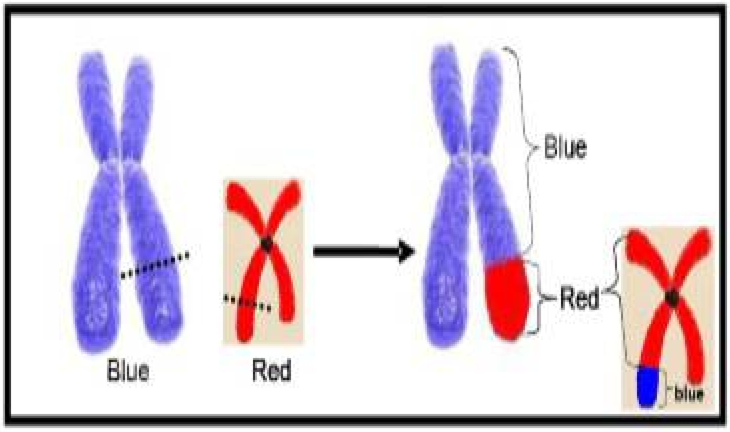
Modeling clay of varied color

Procedure:

A. Translocation

1. Using modeling clay make models of two (2) chromosomes. One should have a different color and size from the other.

2. Break one part of each of the chromosomes. Exchange the parts and attach them to each of the other chromosomes. See illustration below.

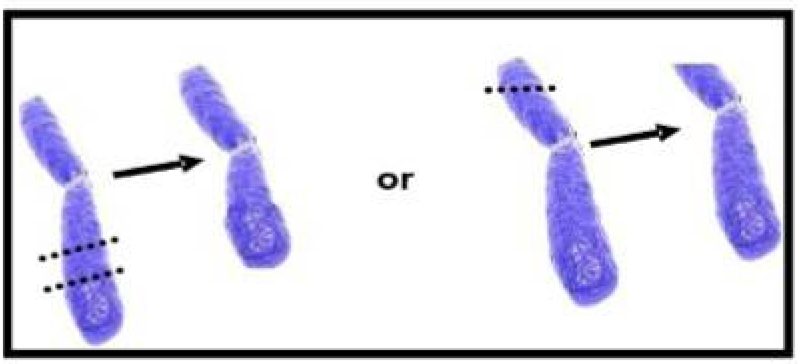


3. Fill in the second column (translocation) of the table.

B. Deletion

1. Make a model of a chromatid (one of the duplicated copies of a chromosome).

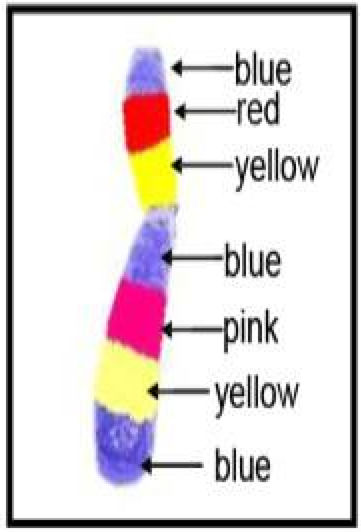
2. When done, remove a portion of it (close to either end of the chromosome or within the long arm or short arm). If you choose to remove a part within the arms, be sure to join back the bottom part. See sample illustration.



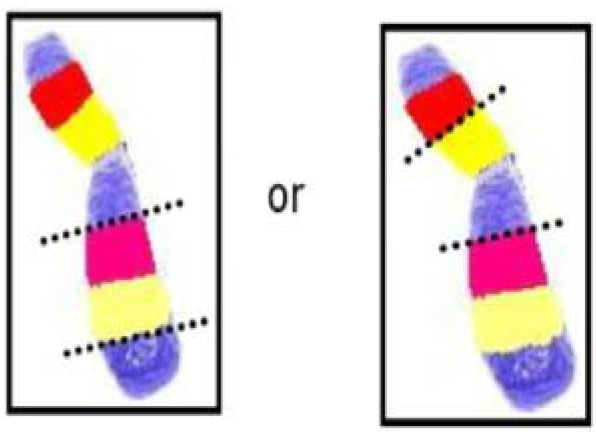
3. Fill in the third column (deletion) of the table.

C. Inversion

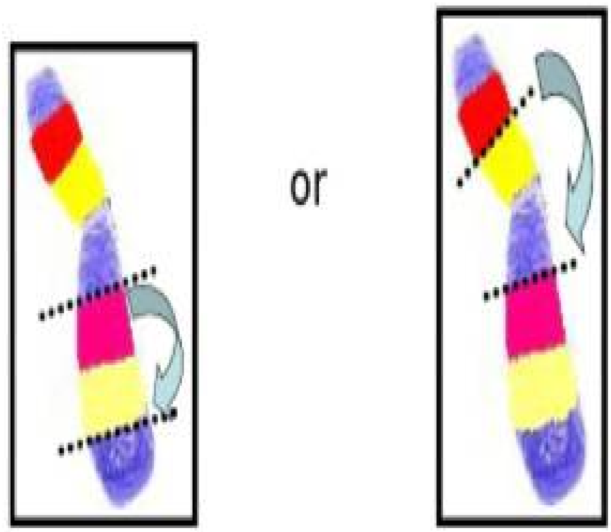
1. Make a colored chromatid as shown below.



2. This time break a portion (with 2 colors) of it. Refer to the illustration below.



3. Reinsert it to the chromatid in reverse manner.



4. Fill in the fourth column (inversion) of the table.

	Chromosomal Mutations		
	Translocation	**Deletion**	**Inversion**
1. How many chromosomes are involved?			
2. How did you change the original structure of the chromosomes?			
3. Which condition/s do you think result/s to change/s of chromosome material? Please indicate using the words loss, gain, either loss or gain of genetic material.			

Q22. How are the three chromosomal aberrations different from each other? How are they similar?

Q23. Do you think the normal genetic content of the chromosome is affected?

Q24. Which condition results to gain of chromosome material? Loss of chromosome material?

Q25. What are some possible effects of these chromosomal mutations?

(Activity adapted from BEAM – DepEd Material)

Abnormalities in chromosomal structure may occur during meiosis. The normal process of crossing-over and recombination may be affected, such that chromosomes break and reunite the wrong segments. If there is a loss or gain of chromosomal material, there can be significant clinical consequences.

Changes that affect the structure of chromosomes can cause problems with growth, development, and function of the body's systems. These changes can affect many genes along the chromosome and disrupt the proteins made from these genes. Structural changes can occur during the formation of egg or sperm cells in fetal development, or in any cell after birth. Pieces of DNA can be rearranged within one chromosome or transferred between two or more chromosomes.

The effects of structural changes depend on their size and location, and whether any genetic material is gained or lost. Some changes cause medical problems, while others may have no effect on a person's health.
The gain or loss of chromosome material can lead to a variety of genetic disorders. Human examples are the following on the next page:

Source: player.mashpedia.com
Figure 11. Cri du chat

(a) "*Cri du chat*" is caused by the deletion of part of the short arm of chromosome 5. "Cri du chat" is French, and the condition is so named because affected babies make high-pitched cries that sound like a cat. Affected individuals have wide-set eyes, a small head and jaw, are moderately to severely mentally retarded, and very short.

(b) Down's syndrome is usually caused by an extra copy of chromosome 21(trisomy 21). Characteristics include decreased muscle tone, stockier build, asymmetrical skull, slanting eyes and mild to moderate mental retardation.

Source: www.healthtap.com
Figure 12. Down's Syndrome

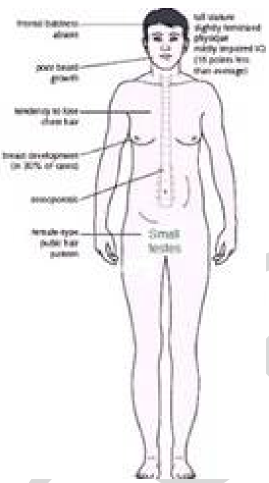
Source: healthtap.com
Figure 13. Edward Syndrome

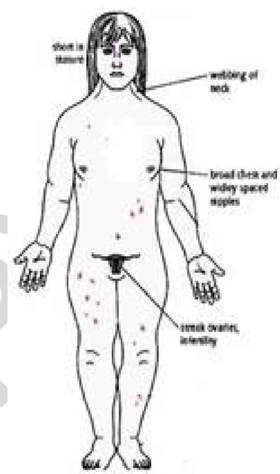
(c) Edwards syndrome, which is the second most common trisomy after Down's syndrome, is a trisomy of chromosome 18. Symptoms include mental and motor retardation and numerous congenital anomalies causing serious health problems. About 99% die in infancy. However, those who live past their first birthday, usually are quite healthy thereafter. They have a characteristic hand appearance with clenched hands and overlapping fingers.

(d) Jacobsen syndrome is also called terminal 11q deletion disorder. This is a very rare disorder. Those affected have normal intelligence or mild mental retardation, with poor or excessive language skills. Most have a bleeding disorder called Paris-Trousseau syndrome.

e) Klinefelter's syndrome (XXY). Men with this condition are usually sterile and tend to have longer arms and legs and to be taller than their peers. They are often shy and quiet and have a higher incidence of speech delay.

(f) Turner's syndrome (X instead of XX or XY). Female sexual characteristics are present but underdeveloped. They often have a short stature, low hairline, abnormal eye features and bone development and a "caved-in" appearance to the chest





Source: http://chengmoh.blogspot.com/2012/08/genetic-diseases.html

Figure 14. E. Klinefelter **Figure 14. F.** Turner

Sources:http://ghr.nlm.nih.gov/handbook/mutationsanddisorders/structuralchangeshttp://www.usd.edu/med/som/genetics/curriculum/1ECHROM3.htm

Human Karyotyping

Occasionally, chromosomal material is lost or rearranged during the formation of gametes or during cell division of the early embryo. Such changes, primarily the result of nondisjunction or translocation, are so severe that the pregnancy ends in miscarriage – meaning loss of an embryo or fetus before the 20th week of pregnancy or fertilization does not occur at all. It is estimated that one in 156 live births has some kind of chromosomal abnormality.

Some of the abnormalities associated with chromosome structure and number can be detected by a test called a karyotype. A karyotype is an image of the full set of chromosomes of an individual that displays the normal number, size, and shape. Karyotypes may reveal the gender of a fetus or test for certain defects through examination of cells from uterine fluid – a procedure called amniocentesis – or through sampling of placental membranes as shown in Figure 15.

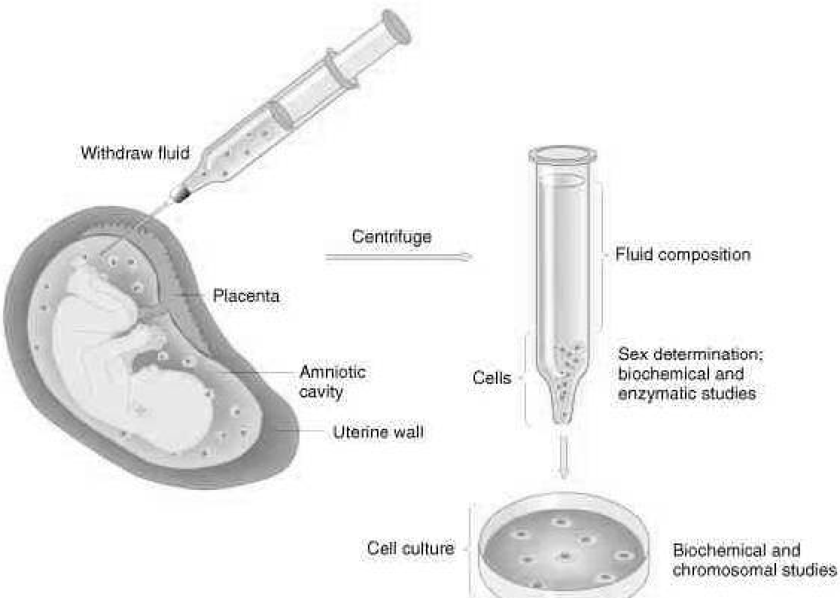
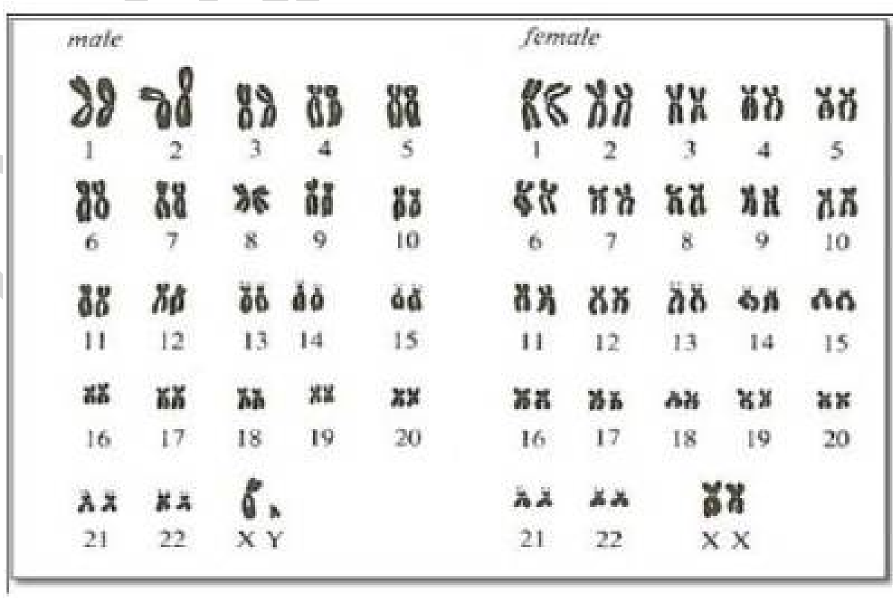


Figure 15. Amniocentesis

To produce a karyotype, chromosomes commonly derived from actively dividing white blood cells are stained and photographed. The homologous pairs of chromosomes are identified and arranged in order by size, with the exception of the sex chromosomes; these appear last as shown in Figure 16. These tests are typically done on a blood sample, although any body cell could be used. The cell must be undergoing mitosis – preferably in metaphase – so that the chromosomes are replicated, condensed, and visible under a microscope.



Source: www.austincc.edu
Figure 16. Karyotype of Human Male and Female

Genetic Engineering

Understanding the gene has led to the remarkable development of methods for changing a cell's DNA. A modern biotechnology called genetic engineering produces transgenic or GM crops of organisms. Scientists have developed methods to move genes from one species into another. When DNA from two different species are joined together, it is called **recombinant DNA**. This process uses restriction enzymes to cleave one organism's DNA into fragments and other enzymes to splice the DNA fragment into a plasmid or viral DNA. Transgenic organisms are able to manufacture genetic products foreign to them using recombinant DNA. Genetic engineering has already been applied to bacteria, plants, and animals. These organisms are engineered to be of use to humans. Figure 17 shows the method for producing recombinant DNA.

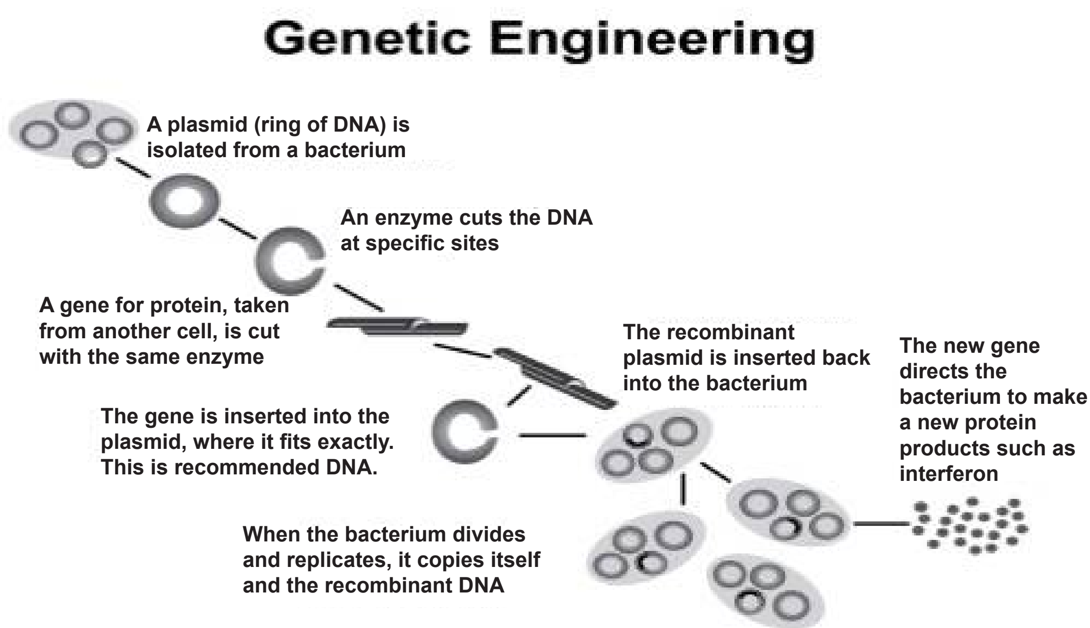


Figure 17. Diagrammatic Illustration of the Steps in Genetic Engineering

Today, molecular biologists are finding applications for recombinant DNA technology: from medical applications, including gene therapy and vaccines; DNA fingerprinting used to identify persons responsible for crimes and provide evidence for identity of dead persons; to the creation of genetically modified crops that are resistant to pesticides, or that make extra vitamins and minerals; to bacteria that can clean oil spills. While the applications of recombinant DNA technology are numerous, its limitations are its potential effects on our ecosystem.

KEY CONCEPTS:

- • A mutation is a change in the base sequence of DNA. Mutations may affect only one gene, or they may affect whole chromosomes.
- Mutations in eggs or sperm affect future generations by transmitting these changes to their offsprings.
- Mutations in body cells affect only the individual and are not passed on to the offspring.
- When DNA from two different species are joined together, it is called recombinant DNA. This process uses restriction enzymes to cleave one organism's DNA into fragments and other enzymes to splice the DNA fragment into a plasmid or viral DNA.

Now that you have learned that protein is made using the information from DNA and how mutations may cause changes in the structure and function of a protein, it would be worth finding out how a deeper understanding of molecular genetics may affect your life. What do you think are the significant contributions of this knowledge to human society? You may share your thoughts and ideas with your classmates.

V. Summary/Synthesis/Feedback

- Deoxyribonucleic Acid (DNA) is the genetic material of organisms. A DNA is a double helix molecule composed of two complementary strands of deoxyribonucleotides units. The complementary base pairs of the DNA are held by hydrogen bonds.

- The central dogma of the transfer of genetic information states that the sequence involved in the expression of hereditary characteristics is from DNA to RNA to proteins.

- Genes are segments of DNA that may code for RNA or proteins.

- Most sequences of three bases in the DNA of a gene code for a single amino acid in a protein.

- Transcription is the process by which the information in a strand of DNA is copied into a new molecule of messenger RNA (mRNA).

- There are three major types of RNA in the cell and their functions:
  1) The mRNA carries the information from DNA to the ribosomes.
  2) The tRNA translates the genetic message carried by the mRNA through protein synthesis.
  3) The rRNA forms the structural component of the ribosome.

- Ribosomal RNA serves as the site for attachment of mRNA and tRNA and for protein synthesis

- Translation is a process which determines the order of bases in mRNA of amino acids into a protein. It occurs in a ribosome in the cytoplasm.

- A mutation is a change in the base sequence of DNA. Mutations may affect only one gene, or they may affect whole chromosomes.

- Mutations in eggs or sperm may affect future generations by transmitting these changes in the offsprings. Mutations in non-sex (somatic) cells only are not hereditary.

- When DNA from two different species are joined together, it is called **recombinant DNA**. This process uses restriction enzymes to cleave one organism's DNA into fragments and other enzymes to splice the DNA fragment into a plasmid or viral DNA.

VI. Summative Assessment

A. Choose the letter of the correct answer:
The following is the base sequence on one strand of a DNA molecule:
A A T G C C A G T G G T

1. If this strand is replicated, which of the following is the complementary strand that is produced?
   a. T C G T C C G T C T A G
   b. A G C A G G C A G G G T
   c. T T A C G G T C A C C A
   d. U C G U C C U C U A G A
2. If transcribed into an mRNA, what would be the resulting strand?
   a. U U A C G G U C A C C A
   b. A G C A G G A G A T C
   c. A G C A G G C A G A U C
   d. T C G T C C G T C T A G
3. During translation, the tRNA sequence of nucleotides arranged linearly is _______.
   a. T C G T C C G T C T A G
   b. A A U G C C A G U G G U
   c. A G C A G G C A G A U C
   d. U C G U C C G U C U A G

B. Each combinations of nitrogen bases on the mRNA molecule is a codon, which is a three letter code for a specific amino acid. The table shows the mRNA codon for each amino acid. Use the Genetic Code Table to answer the questions.

4. The codon for tryptophan is _______.
5. For leucine, there are _______ different codons.
6. The codon GAU is for __________.
7. In a stop codon, if the second base is G, the first and third bases are ____ and ___.

C. Sequence the following steps in protein synthesis from first to last (1-6).
___A. Transcription
___B. tRNA – amino acid units link to mRNA
___C. Amino acid separate from tRNA
___D. Polypeptide chain assembled
___E. mRNA links to ribosome
___F. Stop codon encountered in mRNA

D. Given the list of amino acids, determine the sequence of bases in the codon of the mRNA that codes for these amino acids. Use the table for the Genetic Code.

1. Methionine
2. Leucine
3. Arginine
4. Threonine
5. Lysine
6. Asparagine
7. Valine
8. Glycine
9. Aspartic acid
10. Glutamic acid

Second letter

First letter	U	C	A	G	
U	UUU UUC Phenyl-alanine UUA UUG Leucine	UCU UCC UCA UCG Serine	UAU UAC Tyrosine UAA Stop codon UAG Stop codon	UGU UGC Cysteine UGA Stop codon UGG Tryptophan	U C A G
C	CUU CUC CUA CUG Leucine	CCU CCC CCA CCG Proline	CAU CAC Histidine CAA CAG Glutamine	CGU CGC CGA CGG Arginine	U C A G
A	AUU AUC AUA Isoleucine AUG Methionine; initiation codon	ACU ACC ACA ACG Threonine	AAU AAC Asparagine AAA AAG Lysine	AGU AGC Serine AGA AGG Arginine	U C A G
G	GUU GUC GUA GUG Valine	GCU GCC GCA GCG Alanine	GAU GAC Aspartic acid GAA GAG Glutamic acid	GGU GGC GGA GGG Glycine	U C A G

E. Write the sequence of bases in the mRNA molecule from which the protein molecule in letter D was identified.

Glossary of Terms

Amino acid – the building blocks of a protein molecule

Anticodon – the complement of the mRNA; triplet code in the tRNA

Chromosomal mutations – changes in the chromosomes where parts of the chromosomes are broken and lost during mitosis.

Codon – each set of three nitrogenous bases in mRNA representing an amino acid or a start/stop signal

DNA replication – process in which the DNA is copied

Genetic code – set of rules that specify the codons in DNA or RNA that corresponds to the amino acids in proteins

mRNA	messenger RNA; brings information from the DNA in the nucleus to the cytoplasm
Mutation	any change in the DNA sequence.
Nitrogenous base	is a carbon ring structure that contains one or more atoms of nitrogen. In DNA, there are four possible nitrogen bases: adenine(A), thymine(T), cytosine(C) and guanine(G)
Recombinant DNA	a form of DNA produced by combining genetic material from two or more different sources by means of genetic engineering.
rRNA	ribosomal RNA; hold tightly to the mRNA and use its information to assemble amino acids
Transcription	process of copying DNA sequence into RNA.
Translation	process of converting information in mRNA into a sequence of amino acids in a protein.
tRNA	transfer RNA; a type of RNA that attach the correct amino acid to the protein chain that is being synthesized in the ribosome.

References and Links

Printed Materials:

Rabago, L.et al. (2010). *Functional Biology:Modular Approach*. Vibal Publishing House, Inc.

Biggs. A. Gregg, K., et al. (2000). *Biology: the Dynamics of Life.* USA: McGraw-Hill Companies. Inc.

Addison-Wesley (1996). *Science Insights:Exploring Living Things*. USA:Addison Wesley Publishing Company.

Teaching Guide – I*ntegrative Science Biology* by Eferza Publications

Electronic Sources:

www.chemguide.co.uk/organic props/amino acids/dna1.html/

www.accessexcellence.org

www.elmhurst.edu

ghr.nlm.nih.gov/handbook/mutations and disorders/gene mutation

ww.nature.com/scitable/topicpage/Genetic-Mutation - 1127

www.buzzle.com/articles/hybrid-fruits-and-vegetables.html

internalcampaignschools.org

www.scq.ubc.ca

www.shmoop.com

education-portal.com

playermashpedia.com

www.healthtap.com

healthtap.com

http://chengmoh.blogspot.com/2012/08/genetic-diseases.html

www.austincc.edu

DepEd Materials

APEX Biology Unit 6 Anatomy of Genes Lessons 1-5 Heredity and Genetics
BEAM Learning Guide, Nov.2008, Genetic Book of Life pp. 28-34

EASE Biology Lesson 3 The DNA Material pp. 20 -24

Suggested Time Allotment: 8 hrs.

Unit 3
MODULE
3

BIODIVERSITY AND EVOLUTION

I. Introduction

Do you know why dinosaurs no longer exist today? Why some animals before are very different from the animals we have now? From Grade 7 to Grade 9 you have learned that organisms are grouped into Kingdom, Phylum, Class, Order, Family, Genus, and Species. You also learned that organisms possess unique characteristics. Some organisms may look the same but have distinct differences from each other, others may not be related to one another but they have similar functional features and characteristics. You may also wonder why some animals that are present before are no longer existing today. Such extinction of organisms were caused by various environmental factors and human activities.

This module will give you an idea that maintaining individual differences and variety of characteristics are important to ensure the survival of species.

This module will also discuss the different sources of possible evidence for evolution such as fossil records, and developmental and molecular biology which gave way to the different concepts about the origin of life. It will also provide a variety of activities to help you understand the processes and mechanism of evolution.

Through this module, it is hoped that you will be encouraged to further take care of and protect our environment (e.g. natural resources), to ensure the survival of species and conservation of our biodiversity.

II. Learning Competencies/Objectives

At the end of this module you are expected to:

1. Understand how evolution is being studied from the fossil record and molecular data.
2. Give the importance of understanding the origin of life.
3. Explain why reproduction, variation, and adaptation are necessary for the survival of species.
4. Discuss how natural selection promotes expression and propagation of traits and species that adapt with the changing environment.

Key questions for this module:

1. Why are evidences important in the study of origin of life?
2. Explain how reproduction, variation, and adaptation are necessary for survival of species.
3. How can Natural Selection contribute to biodiversity or extinction?

III. Pre- Assessment

I. Multiple Choice. Choose the best answer.

1. Where can most of the fossils be found?
   a. Sedimentary rock
   b. Granite rock
   c. Lava flows
   d. Black soil

2. Which of the following statements DOES NOT describe evolution?
   a. Evolution is continuous.
   b. Evolution refers to change.
   c. The world is stable and unchanging.
   d. If there is mutation, there is evolution.

3. Which pairs of animals show a correct example of homologous structures?
   a. Wings of butterfly and bat.
   b. Flipper of whale and forelimb of cat.
   c. Fingers of human and arm of starfish
   d. Tongue of frog and proboscis of mosquito.

4. In what Era can the oldest fossils be found?
   a. Cenozoic
   b. Mesozoic
   c. Paleozoic
   d. Pre-Cambrian

5. Which of the following statements best explains the Theory of Natural Selection?
   a. Organs that are not used may disappear while organs that are constantly used may develop.
   b. In nature, the organisms with desirable characteristics may survive while those with weaker traits may not.
   c. Organisms develop desirable structures to survive in a given environment.
   d. Acquired characteristics of parents can be passed on to offsprings.

6. Which is a more definite characteristics to show relatedness of two organisms?
   a. Similarity in development
   b. Similarity in courting behavior
   c. Similarity in structure
   d. Similarity in genomic DNA

7. Which of the following statement explains Lamarck's Theory of Use and Disuse?
   a. Body structures develop because they are used extensively
   b. Body structures develop because they are not in use
   c. Body structures develop because of competition
   d. Body structures develop because of mutation

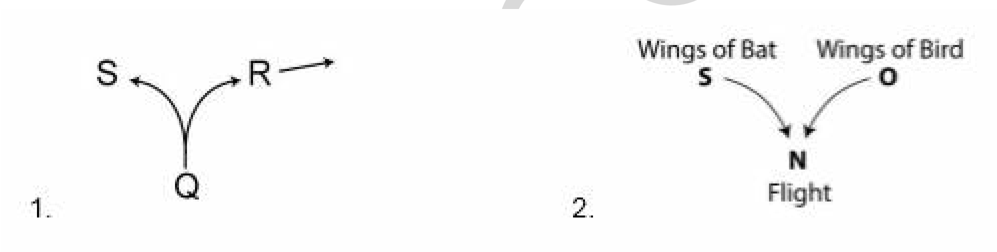
8. Which of the following statements **does not** show the process of adaptation?
   a. Dying out of dinosaurs during Cretaceous period.
   b. Certain group of birds eating different kinds of food.
   c. The finches in Galapagos with different beaks.
   d. A child learning to walk on his own.

9. Why do organisms with close biochemical similarities show stronger evolutionary relationships?
   a. They have varied and different ancestry.
   b. They have similar patterns during their early stages of development.
   c. They have a common ancestor and have the same kind of proteins.
   d. They possess same vestigial structure that made their evolutionary relationship closer.

10. Which of the following statements supports the idea that extinction is necessary?
    a. To give way for other organisms to develop
    b. To let other organisms evolve and progress
    c. To know who is the fittest
    d. All of the above

II. Draw the appropriate graphical representation of the following situations.
   a. Equal population of black peppered moths and white peppered moths inhabit a particular area in the city. After a while, modernization and industrialization came. Because of pollution, white peppered moths did not survive while the dark peppered moths enjoy the smog.
   b. A variety of species of deer lives in a certain part of the forest. But after sometime a new organism was introduced to the wild; the fast deer increased in number, while the slow ones became extinct.

III. Pattern of Evolution. Tell whether the diagrams illustrate convergent evolution or divergent evolution.



IV. Reading Resources and Instructional Activities

SOURCES OF EVIDENCE FOR EVOLUTION

Organisms inhabiting the earth have changed overtime, their structures, traits, and abilities allowed them to adapt and survive in their environment. Data from the fossil records, anatomy and morphology, embryonic development and biochemistry could be analyzed to demonstrate if evolution of life on earth has taken place.

Evidence from Fossil Records

Have you ever seen fossils of any organism? Fossils are examples of evidences that paleontologists use in studying evolution. They are traces of organisms that lived in the past and were preserved by natural process or catastrophic events. They can be remains of organisms which include bones, shells, teeth and also feces embedded in rocks, peat, resin, and ice. Paleontologist is a person who studies fossils.

(a)  (b) 

Sources: (a) www.albertawow.com (b) www.earthhistory.uk

Most fossils were commonly found in sedimentary rocks. They were from the hard parts of the organism like woody stem, bones, or teeth.

(a)  (b) 

Compression | Impression

Source: The Virtual Petrified Wood Museum

Another type of fossil is an imprint or impression. Imprints are shallow external molds left by animal or plant tissues with little or no organic materials present. Compression is the other side with more organic material.

(a)  (b) 

Compression | Impression

Source: The Virtual Petrified Wood Museum

Determining the age of fossils

Do you know how a paleontologist usually determines the age of a fossil? Paleontologists make initial estimates of the age through the position in the sedimentary rocks. Fossils found in the bottom layer are much older than those found in upper layer of rocks.

The following activities will teach us how to determine the age of fossils.

Activity 1A

Where Do I Belong?

Objective:

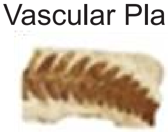
Draw and place the fossil of organisms in its proper Era and Period.

Material:

pen and paper

Directions:

Try to place or draw the fossils of the following organisms in the Era and period where they belong.

Trilobite 	An invertebrate, it lived in a shallow marine environment during Ordovician and Silurian periods.
Crinoid Stem 	Crinoids look like plants but are actually animals related to our modern day starfish. They belong to Phylum Echinodermata and lived during the Triassic Period.
Dinosaur bone 	Dinosaurs or giant reptiles ruled the earth during the Jurassic Period under Mesozoic Era.
Vascular Plant 	This fossilized leaf is once part of an early vascular plant during the Carboniferous Period.

Era	Period	Organism
Cenozoic	Recent	
	Quaternary	
	Teritiary	
Mesozoic	Cretaceous	
	Jurassic	Dinosaurs
	Triassic	Crinoids
Paleozoic	Permian	
	Carboniferous	Vascular Plants
	Devonian	
	Silurian	Trilobites
	Ordovician	Trilobites
	Cambrian	

Source: Images of trilobite and crinoid stem taken from The Virtual Petrified Wood Museum

Q1. Analyze the table above. Which is assumed to be the oldest organism? Why do you think so? What is the probable age of the fossil?

Q2. In what era can you possibly find the most recent fossil? Why do you say so?

Q3. Do you think there are organisms that lived during the Cambrian Period? Explain your answer.

Q4. When do you think did the present day humans first appeared on earth?

Q5. Describe how organisms are arranged in the table.

Relative dating is a method used to determine the age of the rocks by comparing them with the rocks in the other layer. The younger sedimentary rock layer is assumed to be found on top and the older rock is found at the bottom layer. Fossils found at the bottom layer are assumed to be older than those on the upper layer.

The fossils of invertebrates found at the bottom part of the rock layer suggest that invertebrates are probably one of the first and oldest organisms that lived on earth.

Another method is through the use of radioactive isotopes such as carbon-14. Radiometric dating is a method used to determine the age of rocks using the decay of radioactive isotopes present in rocks.

All organisms have decaying carbon-14 in it. Plants and animals that are still alive constantly replace the supply of carbon in their body and the amount of carbon -14 in their body stays the same. When an organism dies, carbon-14 starts to decay.

Carbon dating is used to tell the age of organic materials. Art collectors use carbon dating to determine if a piece of art work is genuine or not.
Do you want to know how to determine the age of a fossil? Try this activity.

Activity 1B

What's My Age?

Objective:

Determine the age of fossil.

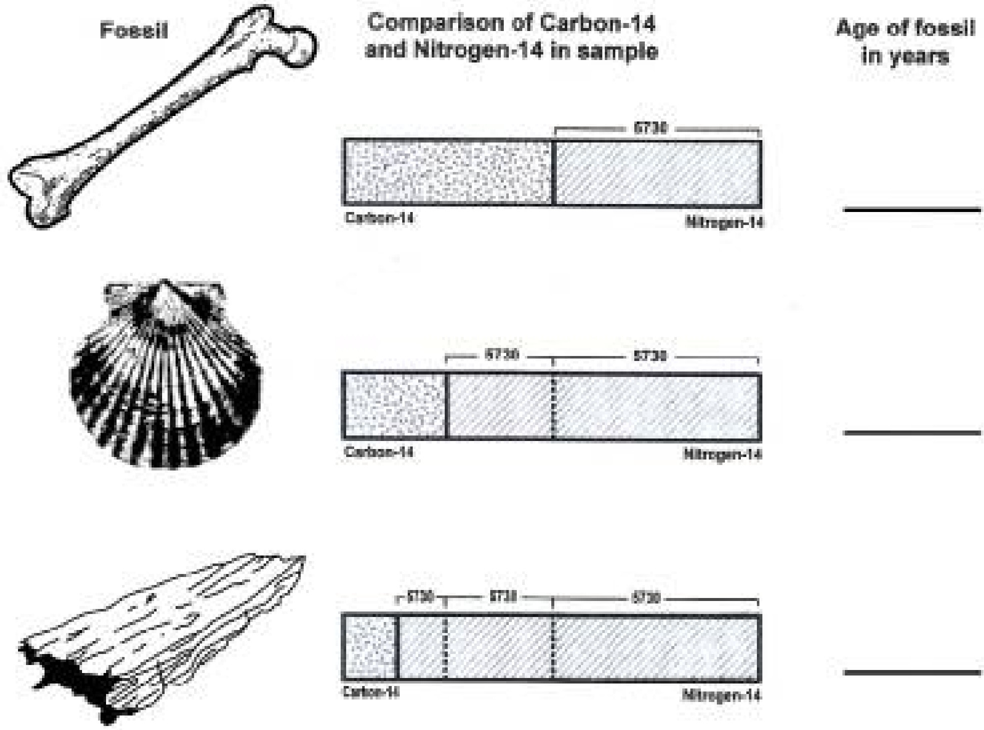
Materials:

- Paper
- pen

Directions:

Use the information below to answer the age of the fossils.

One way scientists determine the age of fossils is by checking the amount of radioactive carbon-14 in the fossil. Carbon-14 breaks down or decays to form nitrogen-14; the rate of this decay is constant e.g. half of the remaining Carbon-14 breaks down every 5730 years. Use this information and compute the age of the fossils on the next page.



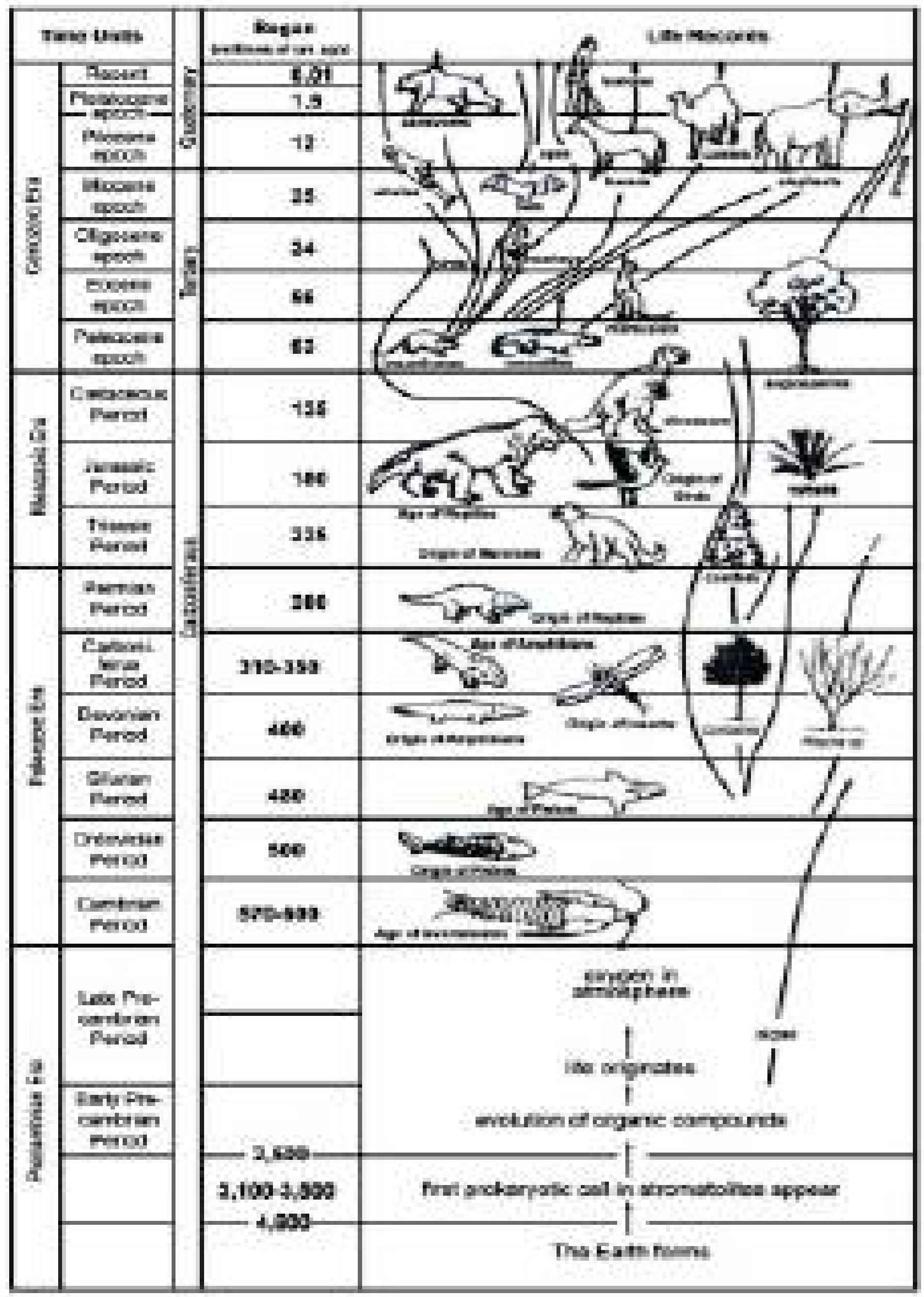
Source: Payawal P. (1993)

Q6. What is the oldest fossil?

Q7. Why is it important to know the age of the fossil?

Out of the examination of layers of rocks and dating fossils, scientists were able to develop the Geologic Time Scale. The Geologic Time Scale shows the major events in the Earth's history. It also shows the appearance of various kinds of organisms in a particular period of time on earth.

GEOLOGIC TIME SCALE



Source: Biology- Science and Technology II Textbook, 1990.

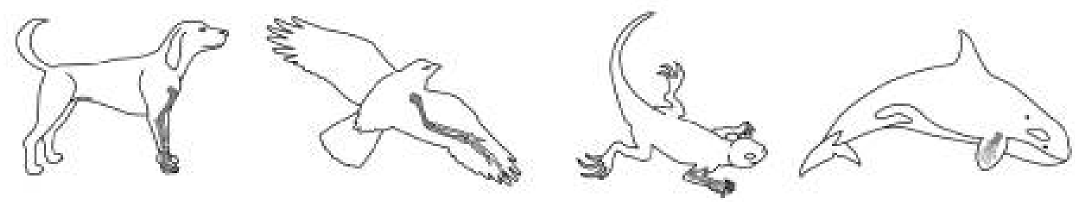
Era is the largest division of Geologic Time Scale, namely Precambrian, Paleozoic, Mesozoic, and Cenozoic. Each Era is further divided into Period.

Looking at the Geologic Time Scale, can you determine how old is the Earth? Do you have any idea why particular organisms exist in every period or era?

Hint of Evolution from Comparative Anatomy

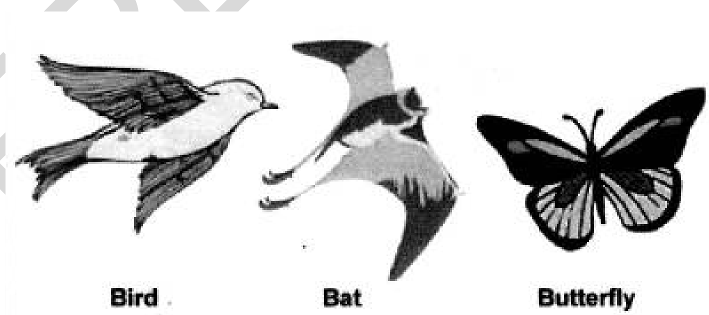
Another hint of evolutionary concept is from the comparative anatomy. Structures from different species which have similar internal framework, position, and embryonic development are considered to be homologous.

Homologous structures may perform different functions in the species living in the different environment, or it may have the same origin but different functions.



Here are some example of homologous structures: forelimbs of dog, bird, lizard, and whale, which are structurally the same, but functionally different.

Structures of unrelated species may evolve to look alike, because the structure is adapted to similar function. These are called analogous structures. Analogous structures have similar functions but different origin.



Examples are wings of birds, bats, and insects that have the same function but different in origin.

Q8. Can you give some examples of analogous structures? What are those?

Activity 2

AHA! Analogous! Homologous!

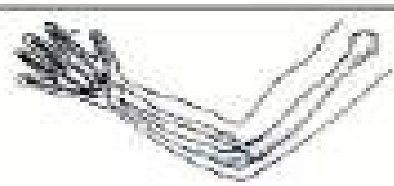
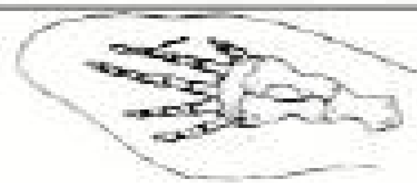
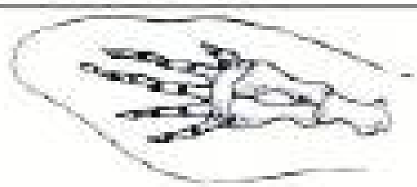
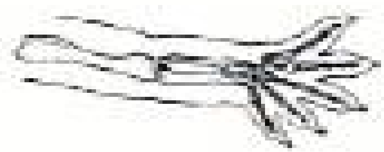
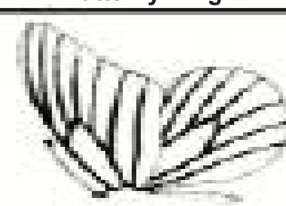
Objectives:

- Distinguish homologous structure from analogous structure.
- Explain the relevance of comparative anatomy as an evidence of evolution.

Materials:

- paper
- pen

Directions: Write in the space provided **H** if the structures below are homologous and **A** if they are analogous.

Structure		Classification
 Human arm	 Whale flipper	
 Human arm	 Alligator forelimb	
 Bat wing	 Butterfly wing	
 Bird wing	 Butterfly wing	

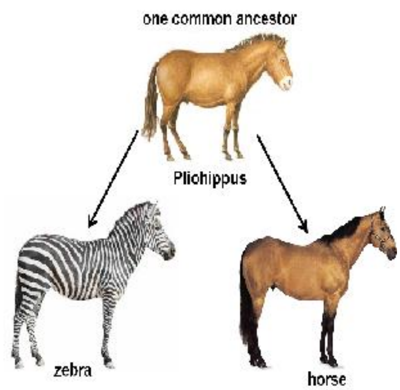
Activity from Payawal P. (1993)

Q9. Can you say that human, whale and bat might belong to a common ancestral group? Explain why.

Q10. Give other examples of homologous structures.

Front limbs of man, cat, horse, bat, whales, and other mammals are made up of same kinds of bones, they just vary only in size and function differently.

Divergent evolution

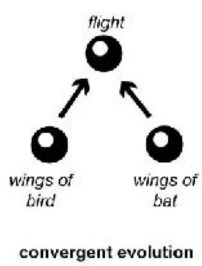


Source: pixgood.com (Pliohippus), pixshark.com (horse), background-kid.com (zebra)

The presence of homologous structures is a strong indicator that the organisms evolved from common ancestors. This type of evolution is called divergent evolution.

Divergent evolution is the splitting of an ancestral population into two or more sub-populations that are geographically isolated from one another.

Convergent evolution



Convergence is an increase in similarities among species derived from different ancestors as a result of similar adaptation to similar environment.

In convergent evolution, analogous structures of unrelated organisms from different ancestors develop similar function such as butterfly wings and bird wings.

Is it true that humans are related to other organisms? If yes, then who's your relative?

Activity 3

So, Who is My Relative?

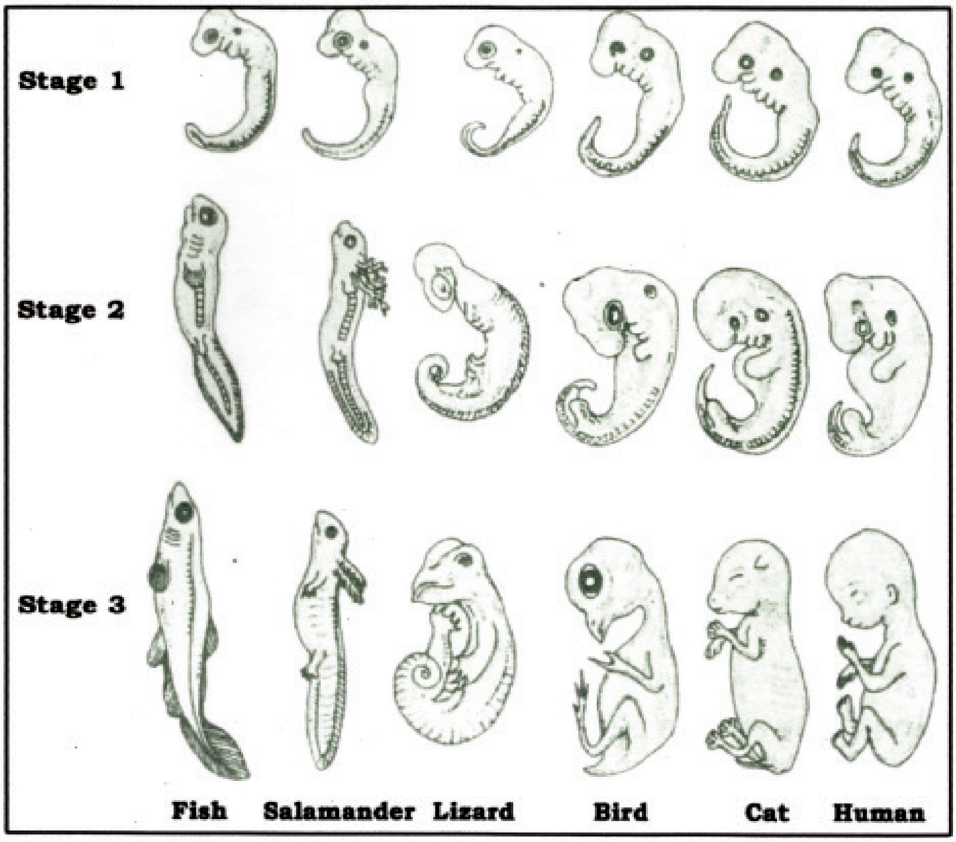
Objectives:

- Compare the stages embryonic development of different organisms.
- Explain how embryonic development provides clues for evolution.

Materials:

- paper
- pen

Directions: Study and compare the stages of embryonic development of the different vertebrates.



Source: Carale (1989)

Q11. In what stages of development of the organisms above show similarities?

Q12. Identify the structure, how and where are they similar?

Q13. In stage 3, identify the structures that made the organisms different from each other?

Q14. Can embryonic development be an evidence that evolution took place? Explain.

Evidence from Embryonic Development

An embryo is an early stage of development in organisms. Embryonic development include stages such as blastula, gastrula, and organogenesis. The embryo of fishes, salamanders, lizards, birds, cats, and humans are similar during the first stage of their embryonic development; and have several homologous structures that are not present when the organisms are adults

Studies show that species that are closely related exhibit similar embryonic development. Even when in the adult stage, the organisms are quite different.

After the three activities, you've learned that fossil records, anatomical structures and embryonic development can be used to study the relationship of organisms. Another evidence of evolution is provided by the biochemical analysis and amino acid sequence of the organisms' DNA. The next activity will further help you understand more the relationship of organisms based on their amino acid sequences.

Activity 4

Let's Compare

Objectives:

- Compare the sequence of amino acids in the cytochrome C of the different vertebrates.
- Infer about the evolutionary relationship of the organisms from the differences in amino acid sequence.

Materials:

- Pen
- paper
- graphing paper
- coloring materials.

Procedures:

1. Given are the sequences of amino acids in the cytochrome C of the human, chimpanzee, gorilla, Rhesus monkey, horse, and kangaroo. Cytochrome C is a respiratory enzyme located inside the mitochondria.

2. Study carefully the sequence of the amino acid.

3. Supply the missing amino acid sequence of chimpanzee, gorilla, Rhesus monkey, horse, and kangaroo to complete Tables 2, 3 and 4. Refer to table 1 for your answer.

4. Identify the differences using the amino acid sequence of human as reference.

5. Complete Table 5 to show the number of amino acid differences and the position which they vary.

Table 1

	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101
Human	THR	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Chimpanzee	THR	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Gorilla	THR	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Rhesus monkey	GLN	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Horse	ALA	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Kangaroo	LYS	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU

	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116
Human	ASN	PHE	ARG	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Chimpanzee	ASN	PHE	ARG	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Gorilla	ASN	PHE	LYS	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Rhesus monkey	ASN	PHE	LYS	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Horse	ASN	PHE	ARG	LEU	LEU	GLY	ASN	VAL	LEU	ALA	LEU	VAL	VAL	ALA	ARG
Kangaroo	ASN	PHE	LYS	LEU	LEU	GLY	ASN	ILE	ILE	VAL	ILE	CYS	LEU	ALA	GLU

Activity taken from Brittain T. (Biology the Living World) Lab Manual, 1989

Table 2

	87	88	89	90	91	92	93	94	95	96
Human	THR	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU
Chimpanzee	__	__	__	__	__	__	__	__	__	__
Gorrilla	__	__	__	__	__	__	__	__	__	__
Rhesus monkey	__	__	__	__	__	__	__	__	__	__
Horse	__	__	__	__	__	__	__	__	__	__
Kangaroo	__	__	__	__	__	__	__	__	__	__

Table 3

	91	98	99	100	101	102	103	104	105	106
Human	HIS	VAL	ASP	PRO	GLU	ASN	PHE	ARG	LEU	LEU
Chimpanzee	__	__	__	__	__	__	__	__	__	__
Gorilla	__	__	__	__	__	__	__	__	__	__
Rhesus monkey	__	__	__	__	__	__	__	__	__	__
Horse	__	__	__	__	__	__	__	__	__	__
Kangaroo	__	__	__	__	__	__	__	__	__	__

Table 4

	107	108	109	110	111	112	113	114	115	116
Human	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Chimpanzee	___	___	___	___	___	___	___	___	___	___
Gorilla	___	___	___	___	___	___	___	___	___	___
Rhesus-monkey	___	___	___	___	___	___	___	___	___	___
Horse	___	___	___	___	___	___	___	___	___	___
Kangaroo	___	___	___	___	___	___	___	___	___	___

Table 5

Organism	Number of amino acid differences
Human and chimpanzee	
Human and gorilla	
Human and Rhesus monkey	
Human and horse	
Human and kangaroo	

Activity taken from Brittain T. (Biology the Living World) Lab Manual, 1989

Q15. Based on the activity, which organism is closely related to humans?

Q16. Which organism is least related to humans?

1. Study tables 6 and 7 below.

Table 6

Species Pairings	Number of Differences in Amino Acid
Human - chimpanzee	0
Human - fruit fry	29
Human - horse	12
Human - pigeon	12
Human - rattlesnake	14
Human - red bread mold	48
Human - rhesus monkey	1
Human - screwworm fly	27
Human - snapping turtle	15
Human - tuna fish	21
Human - wheat	43

Table 7

Species Pairings	Number of Differences in Amino Acid
Fruit fly - dogfish shark	26
Fruit fly - pigeon	25
Fruit fly - screwworm	2
Fruit fly - silkworm moth	15
Fruit fly - tabacco hornworm moth	14
Fruit fly - wheat	47

2. In a graphing paper, plot the information on Table 6 and Table 7 in a bar graph, and use different colors to represent each pairing of species.

Q17. What organism appears to be least related to humans?

Q18. In Tables 6 and 7, which pair of organisms appears to be more related to each other? Which pair of organisms is the least related to each other? Why did you say so?

Q19. If the amino acid sequence of the two organisms are similar, would their DNA be also similar? Why?

Q20. Do you think the chimpanzee, gorilla, and humans have a common ancestry? Explain your answer.

The greater the similarity in amino acid sequence, the closer the relationship of the organisms. The organisms which are similar in structure and also possess similarity at the biochemical level could probably have a common ancestor.

Theories of Evolution

Jean Baptiste de Lamarck was the first evolutionist to believe that organisms change over time. Using fossil records as a guide, Lamarck was able to develop three theories; one is The Theory of Need which states that organisms change in response to their environment. Their ability to survive helped them develop characteristics necessary for them to adapt in a given environment.

Next is The Theory of Use and Disuse; which according to Lamarck, organs not in use will disappear while organs in use will develop. Lamarck believed that giraffes before have short necks, but because of the need to survive and in order to reach tall trees for food, they kept stretching their necks until these became longer and able to reach taller trees. These acquired characteristics were believed to be inherited by their offsprings and propagated by the next generation of giraffes. Lamarck called it as The Theory of Acquired Characteristics.

If you change the color of your hair from black to blond, do you think your child can inherit the blond color of your hair? A young lady keeps on using whitening soap and becomes fair? Can her child inherit her acquired fairness?

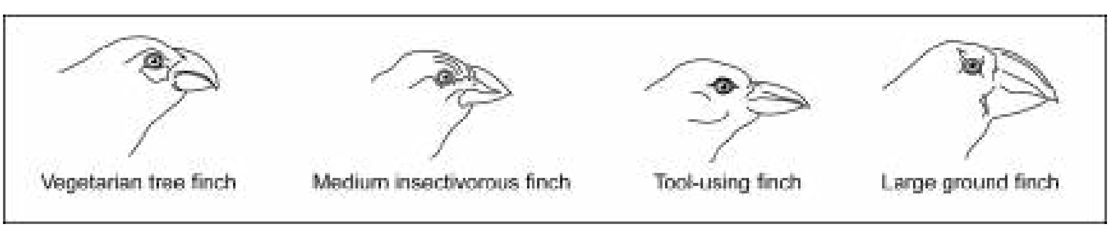
Many scientists rejected the theories of Lamarck. They understood that if there were changes in cell or body structure, there could be changes in the genetic information of the species.

Darwinian Theory

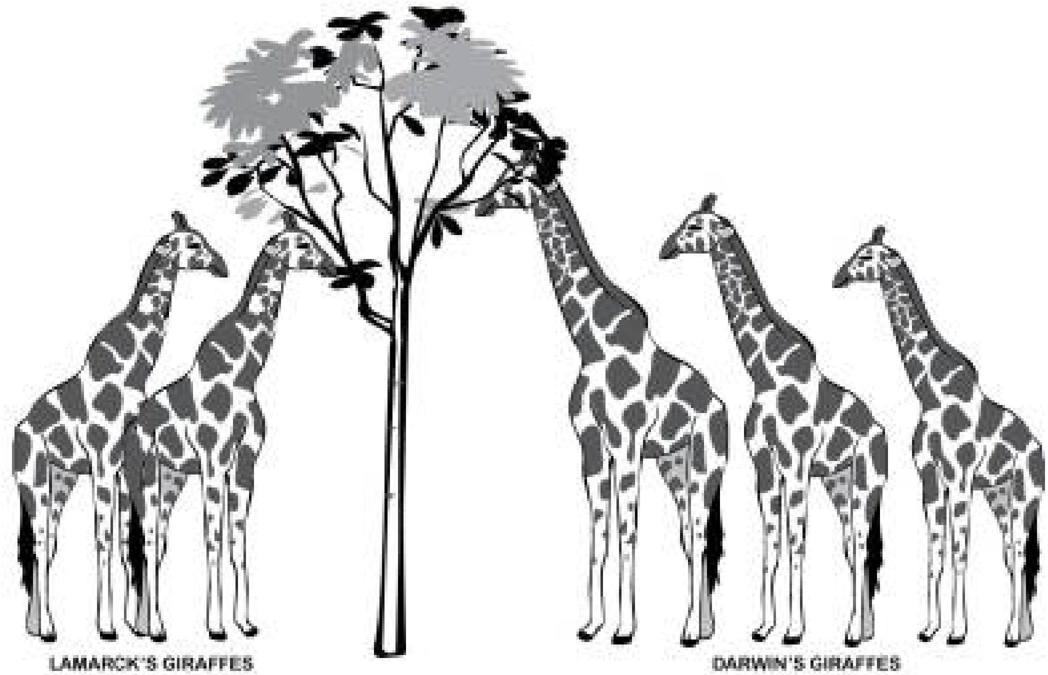
The more popular Theory of Evolution proposed by Charles Darwin based on natural selection is different from the theories of Lamarck. According to Darwin, giraffe species originally had varying neck lengths but natural selection favored the survival of giraffes with longer necks that could feed on taller trees that were available. Giraffes with short neck were eliminated due to lack of accessible food supply.

Fifty years after Lamarck's Theory of Use and Disuse, Charles Darwin suggested the Theory of Natural Selection, after his voyage to the Galapagos Island in HMS Beagle. He was fascinated by the diversity of organisms he found along the journey.

In Galapagos Island, he observed that finch species have different beak structures for different food types. The abundance of certain finch species in an island was somehow related to the type of available food for these birds.



Darwin suggested that selection also takes place in nature. In selective breeding, farmer identifies and selects the best and desirable trait to propagate. In natural selection, environmental factors promote the survival of the fittest and eliminates the less fit.



Activity 5

Follow the Track

Objective:
- Explain the Theory of Natural Selection.

Materials:
- pen
- paper

Procedure:
1. Observe the set of footprints in the diagram.

2. Try to tell a story about the different events.

3. Predict what can probably happen at the end of the diagram.

Q21. In Diagram 1, how many sets of footprints are there? Based on the size of footprints, describe the organisms.

Q22. In what directions are the footprints going?

Q23. Describe or predict what is happening in Diagram 3. In Diagram 4.

Create your own story using the four diagrams and share it to the class.

Organisms struggle for existence in order to survive; they compete for food and space. Organisms with favorable and advantageous characteristics survive and reproduce. Fitness refers to the ability of an organism to survive and produce offsprings. Different individuals in a population possess different characteristics and abilities. This is called variation.

Variation among individuals in the population would likely bring greater chance of survival. An organism that is adapted and has structures fitted to survive in a given environment would likely produce offsprings.

Activity 6

Survivor

Objective:

Determine the effect of environmental changes on adaptation and survival of a species.

Materials:

Tray (made up of chicken wire, 30 cm x 25 cm long and 4 cm thick), surgical mask, alcohol lamp, magnet, rags or mittens, glass of tap water, 25 pieces of marbles, paper clips, paper square (1.5 cm x 1.5 cm), candles, (1.5 cm x 1.5 cm), plastic cellophane (1.5 cm x 1.5 cm)

Procedure:

1. Place inside the tray, 6 pieces each of marbles, paper clips, square paper, plastic cellophane, and candles. Spread them thoroughly on the tray.

2. Hold the tray with a mitten and run it over an alcohol lamp for one minute. **Be careful while working with an alcohol lamp.**

3. Remove the burnt materials and record the "survivors" or those that did not get burned.

4. For every one survivor, add two offsprings. (Ex. for one marble, add two more marbles.)

5. Run along the magnet on the tray.

6. Count the number of survivors. Repeat procedure 4.

7. Using a glass of water, sprinkle water inside the tray.

8. Remove the wet and destroyed organisms on the tray.

9. Count and record the number of survivors and repeat procedure 4.

Disturbances				
Materials/ Organisms	**Fire (alcohol lamp)**	**Earthquake (magnet)**	**Flood/ typhoon (water)**	**Total number of survivors**
Marbles				
Paper				
Candles				
Plastics				
Paper Clips				

Q24. Which of the organisms has the most number of survivors?

Q25. Are there organisms that decrease in number or did not survive the three environmental disturbances?

Q26. Compare and contrast the characteristics of organisms that survive and did not survive the three environmental disturbances.

Q27. How can changes and disturbances in the environment affect the survival of the species?

Your lesson in Grades 8 and 9 will affirm that genes can be transferred from parents to offspring. You also learned that the combined genes of parents will bring about variation of traits.

Variation increases the chance of survival of living things. Organisms with the best and desirable traits would likely adapt to environmental changes and may gradually become better suited to survive in a given environment.

Organisms which are best adapted to the environment will continue to reproduce and perpetuate their own kind. Mating between surviving populations of the same species may shift the abundance of a new breed of organism because of mutation, gene combination, and natural selection. This then leads to speciation and may subsequently increase biodiversity.

Q28. Can destruction of our natural resources affect the survival of species? How?

Q29. In what way can you help to protect our natural resources and save our biodiversity?

Do you want to survive in any given environment or situation? Better equip yourself with things and skills you need in order to survive.

Performance Task

After learning about variation and adaptation you will now create a multimedia presentation about the things an individual must do in order to adapt and survive in environmental changes and challenges.

You can express your thoughts and ideas from the point of view of an environmentalist, a climate change advocate, a mayor or governor of a particular town or a barangay official. Your presentation should cater to the common citizens to encourage them to be aware of environmental changes that can occur, to prepare them for things they need to do, and to help them adapt and survive in these environmental changes. You can interview people from Department of Environmental and Natural Resources (DENR), Climate Change Commission, National Disaster Risk Reduction and Management Council (NDRRMC), and other government agencies and Non-Government Organization (NGO's) where you can gather information that will help you with your presentation.

Your multimedia presentation will be graded accordingly using a rubric. It will be assessed based on purpose, content, understanding of the concepts, additional information, and creativity.

V. Summary/Synthesis/Feedback

- Species may change over time. Fossil records, Developmental and Molecular Biology and Genetics may provide possible evidence for evolution.
- Patterns in animal development suggest that some organisms may have one common ancestor.
- Evidence in structure and molecular studies suggests that organisms are related with one another.
- Jean Baptiste de Lamarck proposed The Theory of Need, The Theory of Use and Disuse and The Theory of Acquired Characteristics.
- Charles Darwin presented the Theory of Evolution based on natural selection.
- Speciation or formation of a new species may occur through mutation, gene combination, and natural selection.
- Speciation increases biodiversity.

VI. Summative Assessment

Multiple Choice: Directions: Choose the correct answer.

1. Where can most of the fossils be found?
   a. Sedimentary rock
   b. Granite rock
   c. Lava flows
   d. Black soil

2. Which of the following statements DOES NOT describe evolution?
   a. Evolution is continuous.
   b. Evolution refers to change.
   c. The world is stable and unchanging.
   d. If there is mutation, there is evolution.

3. Which pairs of animals shows a correct example of homologous structures?
   a. Wings of butterfly and wings of bat.
   b. Flipper of whale and forelimb of cat.
   c. Fingers of human and arm of starfish
   d. Tongue of frog and proboscis of mosquito.

4. In what era can the oldest fossils be found?
   a. Cenozoic   c. Paleozoic
   b. Mesozoic   d. Pre Cambrian

5. Which of the following statements best explains the Theory of Natural Selection?
   a. Organs that are not used may disappear, while organs that are constantly used may develop.
   b. In nature, the organism with desirable characteristics may survive, while those with weaker traits may not.
   c. Organisms develop desirable structures to survive in a given environment.
   d. Acquired characteristics of parents can be passed on to offsprings.

6. According to evolutionists, which is the best test to show the relatedness of two organisms?
   a. Similarity in development
   b. Similarity in courting behavior
   c. Similarity in structure
   d. Similarity in genomic DNA

7. Which of the following statements explains Lamarck's Theory of Use and Disuse?
   a. Body structures develop because they are used extensively
   b. Body structures develop because they are not in use
   c. Body structures develop because of competition
   d. Body structures develop because of mutation

8. Based on the number of differences in amino acid sequence, which pair of organisms is least related to each other?
   a. Fruit fly-wheat
   b. Human-horse
   c. Fruit fly- pigeon
   d. Human - wheat

9. Why do organisms with close biochemical similarities show stronger evolutionary relationships?
   a. They have varied and different ancestry.
   b. They have similar pattern during their early stage of development.
   c. They have a common ancestor and have the same kind of proteins.
   d. They possess same vestigial structure that made their evolutionary relationship closer.

10. Which of the following statements supports the idea that extinction is necessary?
    a. To give way for other organisms to develop
    b. To let other organisms evolve and progress
    c. To know who is the fittest
    d. All of the above

Test II. Identify whether the following statements describe convergent or divergent evolution.

1. Two organisms which live in a certain area developed the same characteristics after a while.

2. A population of certain organisms went separate ways and developed different structures.

For numbers 3 and 4, draw the appropriate graphical representations of the following situations.

3. Three species of lizards inhabit a particular area in a forest; the heavily pigmented lizard, medium pigmented, and lightly pigmented lizard. After the introduction of new species of birds, only the heavily pigmented lizard increased in number; the medium and light pigmented lizard disappeared in the forest.

4. According to Charles Darwin, the necks of giraffes vary in length: the long neck, medium neck, and short neck. Shortage of food and competition made the short and medium neck giraffes disappear, while the giraffes with long necks survived.

Glossary of Terms

Adaptation	ability of an organism to adjust and thrive in a given environment.
Analogous structures	structures in different organisms that are similar in function but different in origin
Convergent evolution	an increase in similarities among species derived from different ancestors as a result of similar adaptation to similar environment
Divergent evolution	an increase in the difference among descendants of a single ancestral species as time passes
Evolution	species change over time
Fitness	ability to survive and produce offsprings
Fossils	remains of once living things, fossil remains include bones, shells, teeth and also feces
Gene	a segment of DNA or RNA that codes for protein or RNA, a molecular unit of hereditary trait

Homologous structures	parts of different organisms that are similar in structure but serve different functions
Reproduction	the process by which an organism produces offspring and thus perpetuate the species
Variation	differences in traits of organisms in a population

References and Links

Printed Materials:

Alexander, P. Bahret, MJ, Charles, J.,Chaves,J.,Courts,G.,D'Allessio,NS., *Biology The Living World,* Prentice hall New Jersey. 1989.

Biology,Science and Technology Textbook, Department of Education, 1990.

Brittain, TM., *Biology: The Living World Laboratory Manual,* New Jersey, USA: Prentice Hall Englewood Cliffs.1989.

Campbell, NA., Williamson, B.,Heyden, RJ., *Biology: Exploring New Life*, New Jersey USA: Pearson Education Inc. 2004.

Capco, CM. Phoenix Science Series: *Biology* Quezon City Philippines: Phoenix Publishing House. 2003.

Carale LR., Galvez, ER. Risa,L. *Biology Science and Technology for Better Life*, Gil Puyat Ave., Makati City Philippines: Basic Media System Inc. 1989.

Delos Reyes, J. *Introductory Biology,* University of the Philippines, Manila: IPPAO. 1995.

Kent, M, *Advance Biology,* Great Claredon St. Oxford USA: Oxford University Press 2000.

Mader, SS. *Biology ,* USA: WM C. Brown Publishing. 1985.

Meyer, DE. *Biological Science a Molecular Approach ,* Boulder, Colorado, USA Biological, Science Curriculum Study . 1980.

Olivares, M., Bermio, E., Cruz J., *Science and Technology for the Modern World*; SEMP II Diwa Scholastic Press Inc. 2003.

Payawal, PC., Lannu, A., Lucia S.D., Sangalang, MF., Soligam, AC., Cadiz, NM., Torreta, NK., *Biology: Study and Review Guide,* Greenhills San Juan, Phil: Academe Publishing House 1993.

Rabago, LM., Joaquin, CC.,Lagunzad, CG. *Functional Biology*, Vibal Publishing 2010.

Reading Essentials for Biology, Teacher Annotated Edition, Glencoe science, McGraw Hill, New York.USA.

Electronic Sources:

http.www.earth history.org.uk

http.www.albertawow.com

http.www.napedu/catalog.php?recor id+13165

http// petrified wood museum.org/imprints.htm

http://serendip.brynmawr.edu/waldron/#evolution

Poole, Lynne Carbon -14. www.chem.uwec.edu

pixgood.com

pixshark.com

background-kid.com

Unit 3
MODULE
4

Suggested Time Allotment: 10-11 hrs.

ECOSYSTEM: BIODIVERSITY

I. Introduction

In Module 3, you have learned how evolution through natural selection can result in biodiversity.

In this module, you will learn how biodiversity can influence the stability of an ecosystem, the relationship between population growth and carrying capacity of a specific environment. You will become aware of the different human activities that have a negative impact on the environment and propose projects (e.g., Clean and Green Project, Sagip Ilog, War on Waste, Urban Gardening, Adopt a River, etc.) that will help protect and conserve the biodiversity you have in your community.

Biodiversity describes how varied are life forms in different ecosystems. The Philippines is known for its very rich biodiversity. According to an article published in the Department of Environment and Natural Resources (DENR) 2014 website, "The country has more than 52,177 described species of which more than half is found nowhere else in the world." On a per unit area basis, the Philippines probably harbors more diversity of life than any other country on the planet. But our country is also considered as a biodiversity hotspot. This is because our country is continuously experiencing an alarming rate of environmental destruction like damage of coral reefs, forests and other similar important resources. Do you know how important biodiversity is? You will find out as you go through this module.

II. Learning Competencies/Objectives

What are expected for you to learn?

1. How diversity of species increases the probability of adaptation and survival of organisms in a changing environment.
2. The relationship between population growth and carrying capacity.
3. The limiting factors that affect population growth.
4. Ways to minimize human impact on the environment.

Key questions for this module:

How does biodiversity affect the stability of an ecosystem?
What are the limiting factors that affect population growth?
How does population growth affect the carrying capacity of an ecosystem?
How do human activities affect the environment?
What can you do to protect and conserve biodiversity in your community?

III. Pre-Assessment

Directions: Fill in the table below to assess your prior knowledge about biodiversity and stability, and identify the skills needed in accomplishing the learning tasks in this module.

K	W	H	L
What do I know?	**What do I want to find out?**	**How can I find out what I want to learn?**	**What did I learn?**
Skills I expect to use:			

IV. Reading Resources and Instructional Activities

Biodiversity and Stability

Biodiversity is a term that describes how varied living things are in a specific area. How many kinds of living things can be found in your community? Think about a place in your community; try to identify organisms that can be found in your locality and are valuable to your life. Why do you consider those organisms important to you?

Organisms are part of biodiversity and may be economically and ecologically valuable. Their products are source of food, medicine, clothing, shelter, and energy. These organisms are also important in maintaining balance in the ecosystem as they performing their specific roles. Some species maintain the quality of natural bodies of water; some prevent soil erosion and floods, cycle minerals in the soil and absorb pollutants. Others feed on insects and pests which control the population of organisms in a certain environment, thus making the ecosystem balance and stable.

The value of species can be divided into various categories:

1. **Direct economic value**
   The species is considered to have direct economic value if their products are sources of food, medicine, clothing, shelter, and energy. For example, some medicines being used nowadays have formulations extracted from plants or animals. Vinblastine and vincristine are two chemicals that have been extracted from rosy periwinkle (tsitsirika in Tagalog) and are used in chemotherapy for Hodgkin's disease and some form of cancer, including lymphocytic leukemia. Another common plant, Vitex negundo (lagundi) is extracted for cough syrup production.

2. **Indirect economic value**
   A species has an **indirect** economic value if there are benefits produced by the organism without using them. For example, certain species maintain the chemical quality of natural bodies of water, prevent soil erosion and floods, cycle materials in the soil, and absorb pollutants.

3. **Aesthetic value**
   A lot of species provides visual or artistic enjoyment, like a forested landscape and the calming beauty of a natural park; or they may be used for spiritual meditation like the Prayer Mountains.

Now it's your turn to classify the value of biodiversity in an ecosystem. This will let you appreciate more the importance of the living things found in your community. Then try to think about how you can help conserve them.

Activity 1

Classifying the Value of Biodiversity*

As a group, you are going to visit a specific area or ecosystem designated by your teacher. You will list down the organisms found in that area and describe the value of the organism. Then you will classify the value by putting a happy face (☺) on the space under the correct column.

Table 1. Organisms and their value

Organism	Value	Direct economic value	Indirect economic value	Aesthetic value
Example: Trees	• Freshen the air		☺	
	• Provide shade		☺	
	• Source of lumber	☺		

*(Adapted from DepEd Science and Technology Biology textbook, pages 326-327)

Biodiversity is very important because it sustains through flow of energy the food web on earth and contributes to environmental stability. **Stability** of an ecosystem can be described as the resilience to withstand changes that may occur in the environment. There are many changes that occur in the environment which may be a result of natural or human activities. These changes may severely reduce biodiversity and result to the instability of the ecosystem.

Now that you appreciated the importance of biodiversity, try to examine how the population of organisms in an ecosystem affects biodiversity.

The Ups and Downs of Population Growth

A population is a group of organisms of the same species that live in a certain area. Ecologists regularly monitor the number of organisms in many populations, but why do they do this? Why should we care if the number of organisms in an area is increasing or decreasing? Well, populations that are growing or diminishing can be indicators of potential problems in the organisms' environment, and such conditions alarm the ecologists if something is going wrong. But it is not enough to simply know if the number of organisms in an area is increasing or decreasing; ecologists need to know why the number of organisms is decreasing. So, one of the main questions ecologists ask themselves is this: Why is a population's size increasing or decreasing?

There are many factors that can cause a population's size to change. But first, you must understand the basic reasons behind why a population increases or decreases. Any population, whether it be that of humans, animals, the mold growing on bread, or the bacteria living in your intestines, will grow if more organisms are being developed (Genetically modified organisms), or born, than are dying. The number of births in a population is called the **birth** rate (natality). The number of organisms that are dying in a population is called the death rate (mortality). Thus, if the birth rate is greater than the death rate, a population will grow. If the death rate is greater than the birth rate, then the population will decrease.

(Adapted from the activity on ecosystem created by Terie Engelbrecht)
Source: http://www.crazyteacherlady.com/uploads/5/1/4/8/5148626/objective_2_activities_pop_growth.pdf

Think about this!

1. The human population is currently growing at an exponential rate. How can this be explained in terms of birth and death rates?

2. The monkey-eating eagle (*Pithecophaga jefferyi*) is considered an endangered species. What does this mean in terms of the birth and the death rate of monkey-eating eagles?

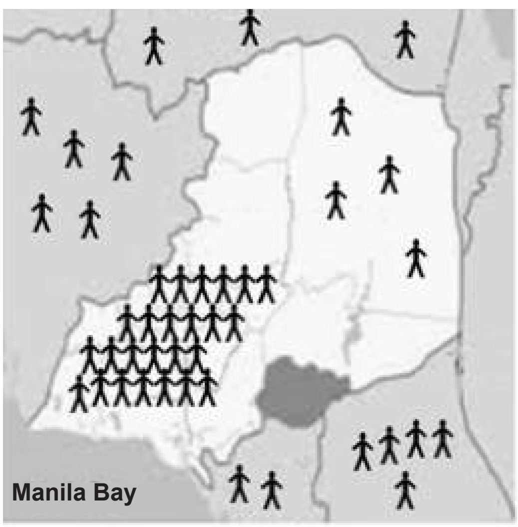


Figure 1. Sample Population Density of people in a certain community

While populations would probably to continue to grow in size, a population of organisms cannot grow forever—its growth will be limited, or stopped, at some point, and the death rate will be greater than the birth rate. A population's growth is limited by two general factors: density-independent factors and density-dependent factors.

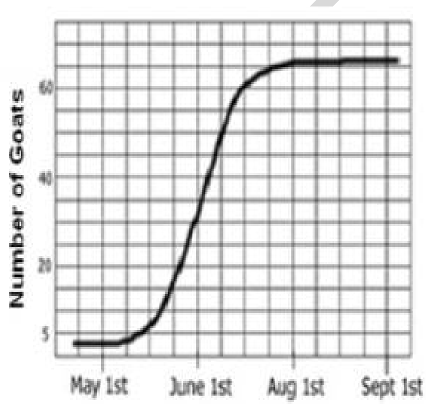
To understand why scientists named these factors in the way they did, you must first understand the concept of population density. Population density refers to the number of organisms per unit area. If a population's density is very high, that means there are a lot of organisms crowded into a certain area. If a population's density is low, that means there are very few organisms in an area.

A factor that regulates a population's growth and is influenced by population density, is called density-dependent limiting factor. If the population's density does not directly influence changes in population's growth, then it is called a density-independent limiting factor.

Density-independent limiting factors that can stop a population from growing can be such things as natural disasters, temperature, sunlight, and the activities of humans in the environment. Natural disasters such as tropical cyclones, floods, earthquakes and fires will stop a population from growing no matter how many organisms are living in a certain area. The same goes for the temperature of an area and the amount of sunlight it receives. If the temperature increases due to global warming, this will cause a decrease in a population's numbers, no matter how large or small the population was to begin with. Human activities that alter the environment will also decrease the number of organisms in a population, regardless of the size of a population.

Density-dependent limiting factors come into play when a population reaches a certain number of organisms. For example, when a population reaches a certain size, there won't be enough resources (food, shelter, water) for all of the organisms. This could cause the population to stop growing when it reaches the maximum number of organisms that can be supported, or "carried," by the environment. This number is known as the population's carrying capacity in a particular environment. Each population of organisms has a different carrying capacity, depending on the amount of resources available in the area in which it lives.

Below is a graph of a habitat where a goat population has reached its carrying capacity:



Q1. What is the carrying capacity?

____

Why? ______________________________

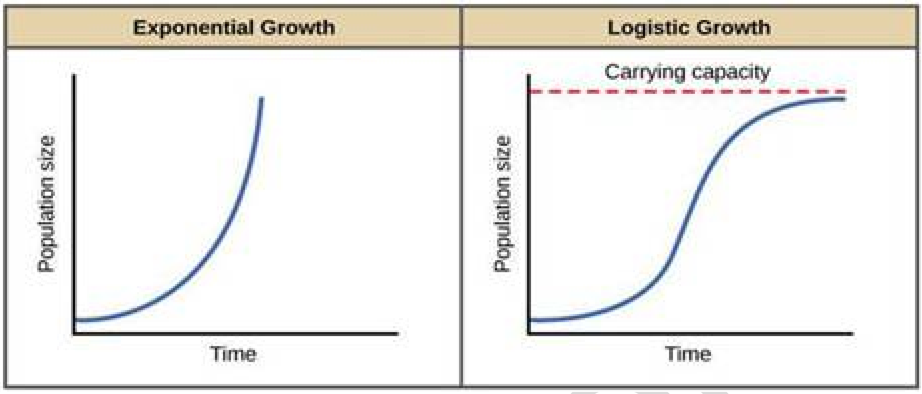
____

Q2. What have you noticed with the population of goat between mid-May and mid-June? ________________________

____

____

Before a population reaches its carrying capacity, it experiences a period of rapid growth. This period of growth is called exponential population growth. During this period, there are plenty of resources available for all organisms, so more births are recorded than deaths in organisms.



When resources are unlimited, populations exhibit exponential growth, resulting in a J-shaped curve. When resources are limited, populations exhibit logistic growth. In logistic growth, population expansion decreases as resources become scarce, and it levels off when the carrying capacity of the environment is reached, resulting in a S-shaped curve.

Source: http://cnx.org/content/m47780/1.1/

Think about this!

3. Fill in the differences of the terms in the chart below:

Density-dependent limiting factor	Density-independent limiting factor
Logistic population growth	Exponential population growth

4. The human population is growing at an exponential rate. Since you have learned that population cannot grow infinitely, what do you think will happen if the human population reaches its carrying capacity? _______
____

Limiting Factors that depend on population density

1. Diseases and parasites – Infectious diseases and parasites spread faster in densely populated areas.

2. Competition for resources - Organism with better adaptations to obtain (food) resources will be able to reproduce more often, and its population will grow. The organisms that have limited abilities to compete for the resources will not reproduce as often, may not be fit enough to live long, and can cause their population to decrease.

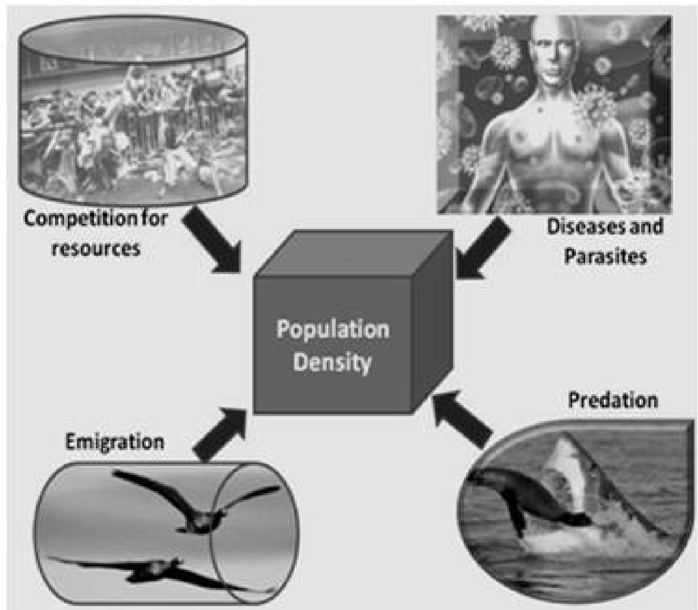


Figure 2. Diagram of Limiting Factors

3. Predation - plenty of prey are available, predators will be able to eat sufficiently, thus have energy to reproduce much, and increase their numbers. The population of their prey will begin to decrease as more and more of them are eaten. However, the predator population will eventually reach carrying capacity—there will not be enough prey for all of the predators in the population, since the predators themselves compete for their "prey" resource. As the number of prey decreases, so will the number of predators, because there is not enough food to sustain them.

4. Emigration - Emigration occurs when, as a population approaches its carrying capacity, and individual organisms leave and go to a new area where they can find enough resources for survival and reproduction. This will obviously cause a decrease in the amount of organisms in a population.

Activity 2

Dependent or independent?

1. Read each situation in the table below, then state if it is a density-independent limiting factor or a density-dependent limiting factor. Indicate the specific limiting factor that is occurring.

Situation	Density-independent or density-dependent?	Limiting factor
Mrs. Rosales has 55 students in her biology class, but she has room for 50. Because the room was crowded, the 5 students were asked to go to the curriculum chairperson to change their schedule.		
Dinoflagellates in Laguna de Bay increase in population due to increase in organic substance in the body of water brought by water pollution.		
The oil spill in Cavite area harmed many aquatic organisms in the vicinity.		
A new strain of Dengue virus breaks out in the country.		
Super typhoon Yolanda caused many residents to leave Leyte.		
Population of wild boar decreases because of deforestation.		
An increase in population of house lizard in Barangay Himpot causes a decrease in population of mosquito.		

2. Cause and Effect
   Read the causes on the left side of the chart then predict and write the effect on the right side of the table.

Cause	Effect
Statistics show that the number of babies born per day doubles the number of death per day.	
Palawan government creates more improvised breeding areas for the endangered marine turtle and coral reef fishes in their area.	
Sharks are hunted and killed for their fins.	

You have learned how a certain activity or phenomena affects the environment; now, try to think of possible solutions to some of the pressing environmental concerns in our country.

Environmental Problems and Issues

The Philippines is considered as one of the biologically richest country in the world because of its high biodiversity at various levels. Our country has both aquatic and terrestrial ecosystems, and also a high degree of endemism, meaning high numbers of native species of flora and fauna are found only in tropical communities.

We have all these rich natural biological resources but we have not truly protected them. We are losing this global heritage due to habitat destruction, overuse and pollution. As our forests are destroyed at a fast rate, the natural habitats which are dwelling places of plant and animal species are also lost. Our coral reefs, where the fishes lay eggs, are badly damaged by destructive fishing methods such as muro-ami, dynamite and fine nets in fishing. In addition, people hunt animals, collect plants, and sell corals and exotic animals for livelihood, and other activities that cause the population of these organisms to decrease at a faster rate. Hence, in view of these harmful human activities, our country is also noted in the world as a hot spot for conservation and protection of species.

The rate of development in some parts of the country is extraordinary. The natural landscape has been changed by tall buildings, establishments, housing projects, expressways, railway systems and overpasses. Other reclaimed areas have been converted into industrial structures and techno parks.

Figure 3. Forested area converted into housing

You may observe similar changes taking place in your community. How do these changes in the community might affect biodiversity in your locality?

For you to provide a good solution you need to analyze these problems. To do that you have to perform the following activities.

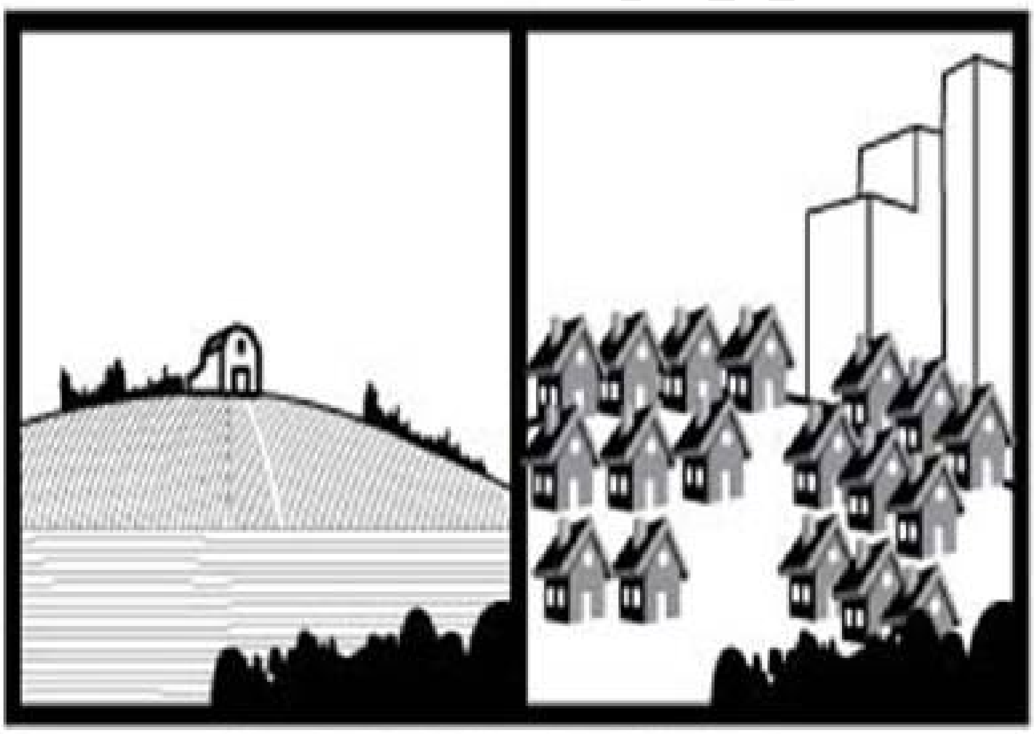
Activity 3

Analyzing Environmental Issues

(Adapted from DepEd Science and Technology Biology Textbook page 345)

Directions: Analyze the problems depicted in the pictures that follow. What effects do these problems create on the ecosystem? What causes these problems?

Problem 1. Farmlands are converted into housing projects



Farmland to Housing Project

Problem 2. River ecosystem dumped with garbage from illegal settlers and toxic wastes from industries.

River to Wasteland

Problem 3. Forested area is converted into technopark.

Forest to Techno Park

You have learned in the previous activity that human activities have impacts on the environment that may have negative or positive result to economic and social attributes of the community.

The next activity will guide you in determining the status of biodiversity in your area and identifying its effect on the economy, environment and social aspects in the locality. Try to think of a possible project proposal that will help conserve or improve this status and lessen the negative impact on the society.

Activity 4

Biodiversity Status in the Community

You need to gather data about the status of biodiversity, population density, and carrying capacity of your locality to determine the effects of these concerns on the economic, environment and social aspects of your community.

A. Use the guide questions below to plan out how you will accomplish this task.

Guide Questions:

1. What will be the task of each member of your group? ____________________
____
____

2. What are the possible questions that you will ask in your survey/interview? __
____
____
____

3. Who are your target respondents for your survey/interview? _______________
____

4. How will you organize the data that you gathered? ________________________
____

5. What are the possible ways that your group can do beyond class hours to complete your learning tasks? ______________________________________
____

Take home task: Conduct a survey or interview at the local Department of Environment and Natural Resources Office (DENR).

B. Analyzing local biodiversity status

Complete the table below based on the data gathered from the survey or interview.

Status of Local Biodiversity	Threats Faced by Local Biodiversity	Local Conservation Efforts	Gaps	Proposed Possible Strategies

Activity 5

Product Creation

Now that you are done with the analysis and plan on how to conserve and protect your local biodiversity, you will produce materials that support the strategies and programs in its conservation and protection. During the creation of your product, you will undergo the cycles of creations: planning, doing reviewing and sharing to ensure quality in your output.

Planning

After learning about the project or ideas, you will be asked to select one project to work on with a group of three to five students. Before beginning with your project, you must first write a project plan and get it approved by your teacher.

Questions to consider:

1. How has your community changed since the time you have lived there?
2. What important issue is your community facing with regards to conservation and protection of local biodiversity? Why is the issue considered a problem or challenge in conserving the local biodiversity?

3. What other information will you need to find out about this issue? Where will you find this information?

4. How is your community likely to change in the next few years?

5. What can people do in the community do to help protect and conserve the local biodiversity?

6. How can you encourage them to participate in this project?

7. What materials do you need for this project?

Planning for your presentation

Work with your group to plan for your presentation. Discuss your answers to the following guide questions. Write your ideas on a sheet of paper.

1. Review the description of the project you will be working on and rewrite the challenges in your own words. Discuss the questions you need to consider.

2. What are the big ideas that you will address in your presentation? Which ones will you need to research and explore further?

3. How will you begin your presentation? What information do you think should your presentation contain? How do you want your presentation to end?

4. What smaller activities might you include as part of your presentation?

5. How will you entertain your audience? Will you have printed materials for them? Will some of your members act, sing, or dance?

6. Who among your group members will work on specific tasks?

7. How long would it take for each member to complete his/her assigned task? Which task/part should be completed first? Which should come last?

Review your presentation plan. Use a rubric as guide and present it to your teacher.

Doing

Now that your group has put together the plan that has been approved by your teacher, you can now start working on your presentation. Remember that you only have few class sessions to complete your work, so it is important that you use your time wisely.

Before you begin your work, meet as a group and review the steps below.

1. Read and check your approved plan. Be sure that everyone knows what task to accomplish.
2. Complete the required research. Use available resources including the data gathered from the survey or interview.
3. Check on your progress using the progress checklist provided by your teacher.

Reviewing

Towards the end of the class session, you should review the work you have completed and consider the following questions:

1. From the information that you gathered, which do you think is not necessary? What other information do you need?
2. How does each completed task help make your big ideas clear?
3. What could be done to make the different parts look like they belong in the same presentation?
4. Make any desired changes. Remember to acknowledge or appreciate the task done by each member of the group.
5. Practice your presentation.
6. As you practice, make sure you take note of all the possible questions that your audience may ask you. Come up with the possible answers in advance.

Activity 6

Showcasing of Products

Your group will give a final presentation to an audience including invited members of the community, parents, teachers and classmates.

In addition, you will watch and listen to other groups' presentation.

A. Review the steps below:
   1. When it is your turn to share, remember to speak slowly and clearly so people can understand what you are saying. When you are finished, allow members of the audience to ask questions.
   2. As other groups give their presentations, watch and listen quietly, pay attention to the information they are sharing. Think about the things you like about the presentation, as well as any questions you may wish to ask later.

V. Summary/Synthesis/Feedback

- Biodiversity benefits people in many ways. It can be of economic, ecological or aesthetic value.
- Greater biodiversity promotes a more stable ecosystem.
- The more recent loss of biodiversity has been attributed primarily to human activities such as overfishing, overhunting, and loss of habitat.
- Population growth gives us an idea on how fast a population changes over time.
- Population growth can be affected by density-dependent or density-independent limiting factors.
- Changes in the habitat may cause an increase or decrease in biodiversity.
- Humans are obliged to take responsibility in maintaining a clean and healthy state of the ecosystem.

VI. Summative Assessment

Directions: Answer the following questions.

A. How should each of the ecosystems below be used to conserve its resources? Explain your choice.

1. Coral reef
   a. Promote it as an ecotourism destination
   b. Collect coral fishes and sell them to pet shops.
   c. Collect corals as souvenir items for tourists.

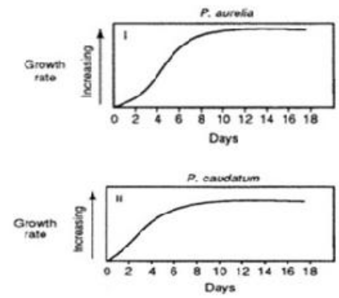
2. Hilly land
   a. Convert it into an industrial area
   b. Build a community where houses are built among the trees.
   c. Turn it into a jogging area

3. Rainforest
   a. Cut the trees into logs and make timber.
   b. Get only minor forest products.
   c. Advertise it as a camping site.

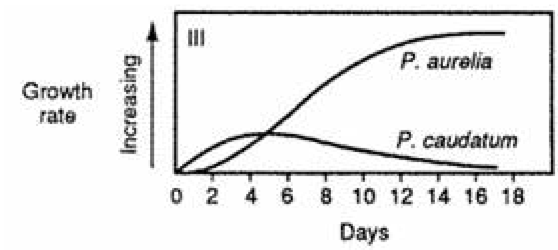
4. Cocolisap infestation outbreak has been declared in some parts of the Philippines. The cocolisap feeds on the sap of the coconut tree and injects toxic enzymes, resulting in discolored leaves and deformed plant tissues that retard its growth of coconut tree. This, results in a decrease of the survival rate of coconut trees. Which of the following factors limit the population of coconut trees?
   a. diseases and parasites
   b. emigration
   c. predation
   d. competition for resources

5. Davao is known for its wide variety of fruits and other plant species that makes it more attractive to tourists. Which of the following classification of value of biodiversity is described?
   a. Direct economic value
   b. Indirect economic value
   c. Ethical/cultural
   d. both a and c

6. What type of population growth is shown in the graph:
   a. normal growth
   b. exponential growth
   c. logistic growth
   d. none of the above



For question no. 7-8 study the graph below.



7. What can you infer about the graph?
   a. The graph shows that an increase in population of the protist *P. aurelia* causes a decrease in the population of *P. caudatum* when they are grown together.
   b. The graph is an example of a density-dependent limiting factor.
   c. The graph is an example of a density-independent limiting factor.
   d. The population of *P. caudatum* decreases while the population of *P. aurelia* increases when they are grown together.

8. Which of the two protists is better adapted to competition?
   a. P. aurelia c. P. caudatum
   b. Both of them d. None of them

9. Which of the following causes a decreasing wildlife population in most of the places in our country?
   a. loss of limiting factor c. loss of habitat
   b. loss of natural disturbances d. loss of carrying capacity

10. A person breeds guinea pigs in a cage. After a few generation, the breeder observes that the guinea pigs are more aggressive towards each other, the young are less healthy and more young guinea pigs die. What do you think will happen to the population of the guinea pigs?
    a. The population will remain the same.
    b. The population will increase.
    c. The population will decrease.
    d. The population is not affected.

Glossary of Terms

Biodiversity	the variety of life forms in a particular ecosystem
Carrying capacity	the maximum number of organisms that an environment can support
Ecosystem	a community of organisms that live, feed and interact with the environment
Exponential growth	a constant increase in the number of population
Limiting factors	factors that control the growth of a population
Logistic growth	a population growth in which the growth rate decreases with increasing number of organisms, until it becomes zero when the population reaches its carrying capacity
Population	the total number of organisms belonging to the same species in a particular environment
Population density	the measurement of population per unit area
Stability	the ability of an ecosystem to be self-regulating, and again become steady after a disturbance

References and Links

Printed Materials:

Dispezio, M.,Luebe, M, et al. (1996). Diversity and Adaptation. In *Science Insights Exploring Living Things* (p. 139). United States of America: Addison-Wesley Publishing Company.

Department of Education Republic of the Philippines (2009). Importance of Biodiversity, Environmental Issues, problems and Solutions. In *Biology Textbook* (pp. 326-327; 344-346). Mandaluyong City, Philippines: Book Media Press Inc.

Glencoe (2000). Ecology. In *Biology The Dynamics of Life* (p. 94; 114). USA: McGraw-Hill Companies.

Rabago, L. (2010). Philippine as Megadiversity Country. In *Functional Biology* (2nd ed., pp. 409-410). Quezon City, Philippines: Vibal Publishing House Inc.

Electronic Sources:

http://www.conservation.org/global/philippines/publications/Documents/Mapping_Population-Biodiversity_Connections.pdf

Activate Instruction (2011, January 11). Study Guide: Population Dynamics | Carrying Capacity | Activate Instruction. Retrieved March 5, 2014, from

https://app.activateinstruction.org/playlist/resource-sview/rid/51ef03ce07121c75158c76f0/id/51ed742a07121cad4fe66a3c/bc0/search/bc1/playlist

Daily, G., & Ehrlrich, P. (1992, November). Population, Sustainability, and Earth's Carrying Capacity A framework for estimating population sizes and lifestyles that could be sustained without undermining future generations, by Gretchen C. Daily and Paul R. Ehrlich. Retrieved March 6, 2014, from http://dieoff.org/page112.htm

DENR (n.d.). Biodiversity Resources. Retrieved March 1, 2014, from
www.denr.gov.ph/index.php/component/content/article/18.html
Elbrecht, T. (2010). ECOLOGY UNIT: POPULATION GROWTH. Retrieved February 28, 2014, from

http://www.crazyteacherlady.com/uploads/5/1/4/8/5148626/objective_2_activities_pop_growth.pdf

Philippine Clearing House Mechanism for Biodiversity (n.d.). Overview on Biological Diversity. Retrieved February 28, 2014, from

http://www.chm.ph/index.php?option=com_content&view=article&id=55&Itemid=55

Skoool.co.uk/ Intel (2004). Population size. Retrieved March 4, 2014, from
http://www.skoool.co.uk/content/keystage3/biology/pc/learningsteps/FSPLC/LO_Template.swf

Teachers try science (2012, January 30). Dynamic Population Dynamics. Retrieved February 28, 2014, from

http://www.teacherstryscience.org/lp/dynamic-population-dynamics

http://cnx.org/content/m47780/1.1./

10

Science

Learner's Material
Unit 4

This book was collaboratively developed and reviewed by educators from public and private schools, colleges, and/or universities. We encourage teachers and other education stakeholders to email their feedback, comments, and recommendations to the Department of Education at action@deped.gov.ph.

We value your feedback and recommendations.

Department of Education
Republic of the Philippines

Science – Grade 10
Learner's Material
First Edition 2015

Published by the Department of Education
Secretary: Br. Armin A. Luistro FSC
Undersecretary: Dina S. Ocampo, PhD

Development Team of the Learner's Material

Authors: Herma D. Acosta, Liza A. Alvarez, Dave G. Angeles, Ruby D. Arre, Ma. Pilar P. Carmona, Aurelia S. Garcia, Arlen Gatpo, Judith F. Marcaida, Ma. Regaele A. Olarte, Marivic S. Rosales, Nilo G. Salazar
Reviewers: Eligio C. Obille Jr., Marlene B. Ferido, Ma. Helen DH Catalan, Vic Marie Camacho, Lilia M. Rabago, Cerilina M. Maramag
Illustrators: Joseph V. Bales, Ramon C. Gatpo, Regaele A. Olarte, Marivic S. Rosales, Ruel C. Quindoy, Antonio I. Basilla, Jose Leo Vic O. Albaño
DepEd Specialists: Joseph R. Jacob, Maria Amparo R. Ventura
Photo Credits: Herma D. Acosta, Dave G. Angeles, Liza A. Alvarez, Ruby D. Arre, Aurelia S. Garcia, Judith F. Marcaida, Regaele A. Olarte, Jane Chavarria, Nilo G. Salazar
Layout Artists: Matthew Daniel V. Leysa and Mary Grace Ann G. Cadisal

Printed in the Philippines by REX Book Store, Inc.
Department of Education-Instructional Materials Council Secretariat (DepEd-IMCS)
Office Address: 5th Floor Mabini Building, DepEd Complex
Meralco Avenue, Pasig City
Philippines 1600
Telefax: (02) 634-1054, 634-1072
E-mail Address: imcsetd@yahoo.com

TABLE OF CONTENTS

Unit 4: Matter and Its Interactions

Overview

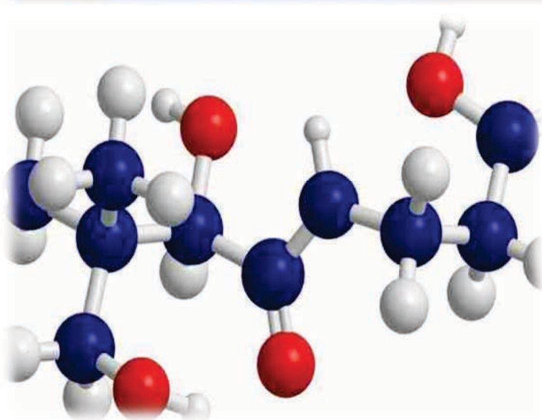
Module 1: Behavior of Gases

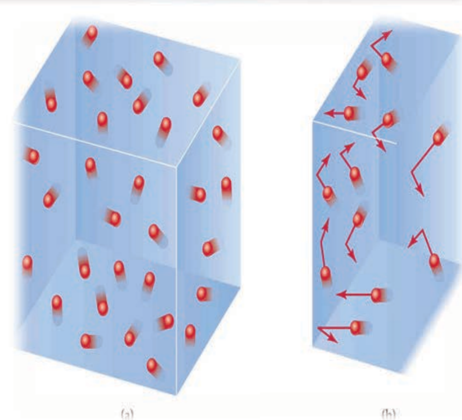
Module 2: Chemical Reactions

Module 3: Biomolecules

UNIT 4

Matter and Its Interactions





Unit 4: Matter and Its Interactions

Overview

In Grade 9, you have learned about chemical bonding and its various types. You have learned how chemical bonding occurs and how particles rearrange to form new substances. Basic mole concept was also introduced to you, relating mass and number of particles of substances. You were also able to analyze the bonding characteristics of carbon which results in the formation of large variety of compounds.

In Grade 10, you will learn that the rearrangement of particles happen when substances undergo chemical reaction. You will get to know how Law of Conservation of Mass applies to chemical reaction by analyzing masses and number of atoms of substances before and after a chemical reaction. Moving up from bonding characteristics of carbon, you will study about biomolecules such as carbohydrates, lipids, proteins, and nucleic acids.

Also in Grade 10 Chemistry, you will investigate how gases behave in different conditions based on knowledge of the motion of and distances between gas particles. You will be able to explain behaviour of gases using the assumptions in the Kinetic Molecular Theory. You will also learn the relationships between volume, temperature, and pressure using established gas laws.

Unit 4 is composed of the following modules:

Module 1: Behavior of Gases
Module 2: Chemical Reactions
Module 3: Biomolecules

Each module is filled with interesting and fun activities that will guide you in your journey to achieving optimum learning.

Let your journey begin…..

Unit 4
MODULE
1

Suggested time allotment: 14 hours

BEHAVIOR OF GASES

I. Introduction

This module offers interesting discussion about gases. You will have a chance to get to know important concepts that will make you appreciate the properties and the behavior of gases.

Most gases are invisible. We can name as many solids and liquids that we see around us but not gases. It is only the very few colored ones like the black smoke produced by smoke belchers that can be seen. Unseen gases are present, to name a few, in a bottle that seems to be empty, in the production of food by the plant, and even in playing our favorite sports. Can you play your favorite sports like volleyball and basketball without the ball sufficiently filled with air or gas? Even our very own existence requires the presence of unseen gases. We take in oxygen and we exhale carbon dioxide. Can we survive here on earth without the desirable gases which support life?

You learned in Grade 8 that like other solids and liquids, gases are also made up of molecules that behave differently. Most of the properties of gases can be attributed to the random and scattered arrangement of its molecules, which are located as far away as possible from each other because they have very weak intermolecular force of attraction.

II. Learning Competencies/Objectives

To keep you on track while you are studying this module, let's have the following learning competencies/objectives in mind:

- Investigate the relationship between:
  - o volume and pressure at constant temperature of a gas;
  - o volume and temperature at constant pressure of a gas.
- Explain the above mentioned relationships using the Kinetic Molecular Theory.

Before you engage yourself in studying this module, please answer the pre-assessment.

III. Pre-Assessment

Direction: Write the letter of the correct answer.

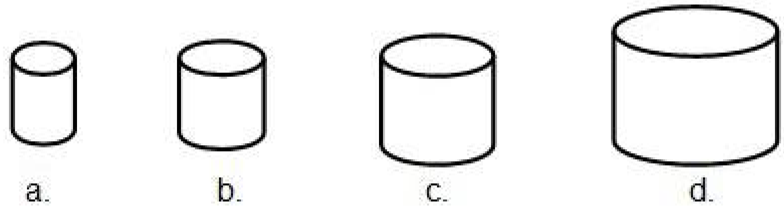
1. Which example has particles that can be drawn closer to occupy smaller volume?
   a. fruit juice
   b. block of wood
   c. air inside the syringe
   d. ice cube

2. Which of the following phenomena does NOT involve the application of gas pressure?
   a. burning fuels
   b. falling leaves
   c. vulcanizing tire
   d. rising hot air balloons

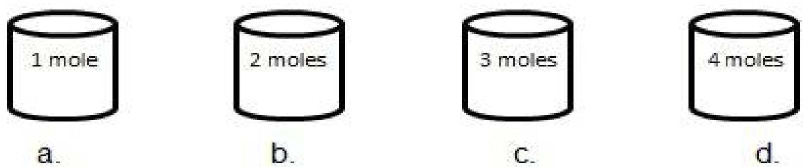
3. Last summer vacation, the Cruz family decided to go to Pagudpod, Ilocos Norte to have a beach party. On their way to Ilocos, all of them were surprised when the tire suddenly exploded. What is the probable explanation for the blown out tire during a long summer drive?
   a. High temperature causes a decrease in volume.
   b. The amount of the gases inside the tire is increased.
   c. The mass of the gases inside the tire increases causing a blown up tire.
   d. The volume of gases increases as the temperature increases, causing a blown up tire.

4. How can you possibly prove that gases have negligible mass?
   a. put a balloon in a digital balance before and after you fill it with air
   b. feel the weight of the samples on both hands
   c. ask two persons to hold a box filled with air
   d. support your claim of through equation

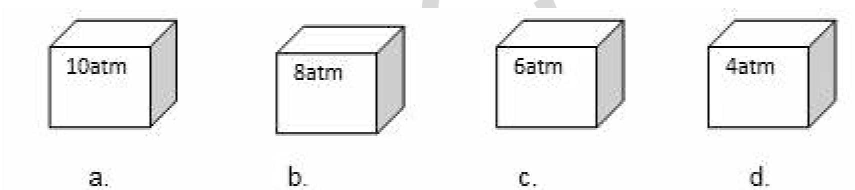
5. Each of the following containers is air tight and has the same number of gas molecules. Which container has the highest pressure?



6. Each of the following containers has the same size. Which of following containers has the most compressed gas molecules?



7. All the gas samples have the same temperature and mass. In which of the following conditions will the gas sample have the highest density?



8. What happens to the density of a gas as its volume decreases at constant pressure and temperature?
   a. decreases b. increases
   c. stays the same d. unpredictable

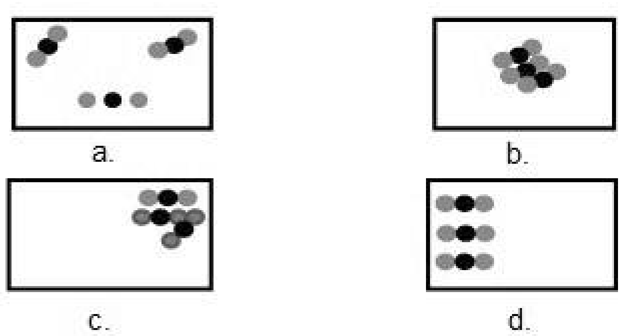
For numbers 9 to11, the choices are:
   a. Boyle's Law b. Charles' Law
   c. Combined Gas Law d. Ideal Gas Law

9. What law explains the mechanism of gas compressor?

10. What gas law best explains the explosion of the heated aerosol container?

11. What gas law explains the relationship among the volume, pressure, temperature, and the number of moles of gases?

12. How will you represent the molecules of carbon dioxide at 30°C?



13. What kind of movement is exhibited by gas molecules?
    a. vibrational movement
    b. rotational movement
    c. translational movement
    d. combination of a, b and c

14. How does the temperature affect the average kinetic energy of gas molecules?
    a. as the temperature decreases the average kinetic energy of gas molecules decreases
    b. as the temperature decreases the average kinetic energy of gas molecules increases
    c. as the temperature decreases the average kinetic energy of gas molecules remains the same
    d. as the temperature decreases the average kinetic energy of gas molecules fluctuates

15. What will happen to the gas pressure as the temperature increases, if the amount and volume of the gas are kept constant?
    a. the gas pressure remains the same
    b. the gas pressure decreases
    c. the gas pressure increases
    d. there is no significant effect

Have your answers checked and keep the result. You will learn about the explanations in your right and wrong answers as you study this module.

Are you familiar with the properties of gases? The first activity will give you ideas on the properties of gases.

IV. Reading Resources and Instructional Activities

Activity 1

Getting to Know Gases

Objective:

Prove that gases have the following properties: mass, volume, temperature, and pressure.

Materials:

For Activity A:

3 rubber balloons of the same kind
digital balance
balloon pump (optional)

For Activity B:

pipette and aspirator or syringe
100-mL graduated cylinder
200 mL water
20 mL cooking oil

For Activity C:

thermometer (360°C)
alcohol lamp
tripod
wire gauze
match
denatured alcohol
ice
500-mL beaker or any tin can

For Activity D:

Erlenmeyer flask
alcohol lamp
tripod
wire gauze
match
denatured alcohol

Procedure:

A. Gases and Its Mass

1. Measure the mass of the deflated balloon using a digital balance with a 0.01 precision (sensitive up to two decimal places).

2. Inflate the balloon using a balloon pump and seal the opening by securely twisting/looping the end.

3. Measure the mass of the inflated balloon using a digital balance.

4. Do three trials and record your data. **Note: Keep the inflated balloon to be used in procedure D.**

Table 1. Data for the Mass of Gas inside the Balloon

Trial	Mass of the deflated balloon (g)	Mass of the inflated balloon (g)	Difference in mass (Inflated-deflated) (g)
1			
2			
3			
Average			

Q1. Is the mass of the deflated balloon different from the mass of the inflated balloon?

Q2. Which is heavier, the inflated or the deflated balloon? Why?

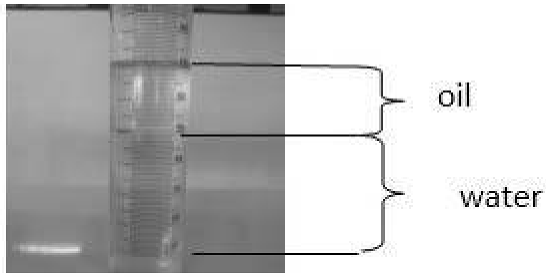
Q3. What can you infer in this activity?

Discover more about gases as you proceed to the next activities.

B. Gases and Its Volume

1. Put approximately 50.0 mL of water in the graduated cylinder.

2. Cover the water with cooking oil up to approximately 70.0 mL. Let the oil settle at the top of the water.



3. Dip the tip of the pipette in the water-oil mixture until it reaches the water portion of the mixture. Carefully press the aspirator at the other end of the pipette to introduce air in the mixture. A syringe can be used as a substitute for pipette.

4. Carefully remove the pipet from the water-oil mixture. Read the final volume after introducing air in the water-oil mixture.

   Note: If pipette and aspirator are not available, you may instead use syringe.

5. Perform three trials and write your data on Table 2.

Table 2. Data for the Volume of Air Trapped in the Water-Oil Mixture

Trial	Volume of water plus oil (mL)	Total volume when air was introduced (mL)	Difference in mass (Inflated-deflated) (mL)
1			
2			
3			
Average			

Q1. What happens to the volume reading of the water-oil mixture when air is introduced to it?

Q2. What does it indicate?

C. Gases and Its Temperature

1. Pour approximately 150 mL of water in a beaker or any tin can.

2. Measure the initial temperature of the air just above the water level.

3. Fill the beaker with crushed ice up to the water level. After 5 minutes, measure the temperature of the air just above the water level.

4. Assemble the wire gauze, tripod, and alcohol lamp. Set aside the iced water. Replace the content of the beaker with tap water. Place the beaker with water on the wire gauze.

5. Heat the water until it boils and get the temperature of the air just above the water level.

6. Perform three trials and write your data on Table 3.

Table 3. Temperature of Water Vapor

Trial	Temperature of the Air (°C)		
	Initial (room temperature)	Above the ice water	Above the boiling water
1			
2			
3			
Average			

Q1. Is there a difference in the temperature of air among the three set-ups?

Q2. Explain the difference in temperature of air.

Note: Use the boiling water for the next set-up.

D. Gases and Its Pressure

1. Transfer the hot water into the Erlenmeyer flask.

2. Carefully place the inflated balloon on the mouth of the Erlenmeyer flask with hot water. Observe what happens.

Q1. What happens to the inflated balloon?

Q2. What causes this phenomenon?

3. Remove the inflated balloon from the Erlenmeyer flask.

4. Get a deflated balloon and place it at the mouth of the Erlenmeyer flask.

5. Assemble the wire gauze, tripod, and alcohol lamp. Heat the Erlenmeyer flask with a deflated balloon.

Q3. What happens to the shape of the balloon?

Q4. What causes the balloon to change its shape and size?

Draw what happens to the balloon.

You have just observed that gases have volume, mass, temperature, and exert pressure. From your daily experiences, can you enumerate some instances where these properties are shown?

The warm temperature we are experiencing is from the heat trapped by the greenhouse gases (carbon dioxide, methane and water vapor to name a few).

The basketball is filled with air. So, it bounces while you are dribbling it. The same is true with the other kinds of ball.

When you open a can or bottle of softdrinks, it fizzes because of the escaping dissolved carbon dioxide due to change of pressure. When the wind blows, it exerts pressure too. There are a lot of manifestations of gases though we cannot see them.

Now that we have proven that gases have mass, volume, temperature, and pressure, let us now be familiar with the units being used to express these properties of gases. Can you identify whether a unit represents volume or pressure or temperature? Below is the list of these units. Start familiarizing yourself with them.

Table 4. Commonly Used Units for Volume and Pressure

Variable	SI Unit	Metric Unit	English Unit
Volume	cubic meter (m^3) cubic decimeter (dm^3) cubic centimeter (cm^3)	liter (L) milliliter (mL)	quart (qt) gallon (gal)
Pressure	Pascal (Pa)	atmosphere (atm) millimeters of mercury (mm Hg) centimeters of mercury (cm Hg)	torr lb/in^2 (psi)

Remembering these equivalents will also be of great help:

Volume units and their equivalents:

$1\ mL = 1\ cm^3$ $1\ L = 1\ dm^3$ $1\ m^3 = 1000\ L$

Source: http://www.metric-conversions.org/volume/cubic-meters-to-liters.htm

Pressure units and their equivalents:

1 atm = 760 mm Hg = 76 cm Hg = 760 torr = 101325 Pa = 14.6956 psi

Temperature units and their equivalents:

0˚C = 273.15 K 0˚C = 32˚F

You will encounter most of these units as we go along. For the meantime, let us investigate if there are interrelationships among the properties of gases. Let us start with the effect of pressure to the volume of gases at constant temperature. Perform the next activity.

Activity 2

Boyle's Law

Objective:

- Investigate the relationship between volume and pressure of gases at constant temperature.

Materials:

- 25 mL syringe
- set of weights
- ruler
- glue stick
- 5" by 3" illustration board
- 6" by 4" by 0.25" wood
- candle or glue gun
- match (if you opted to use candle)

Procedure:

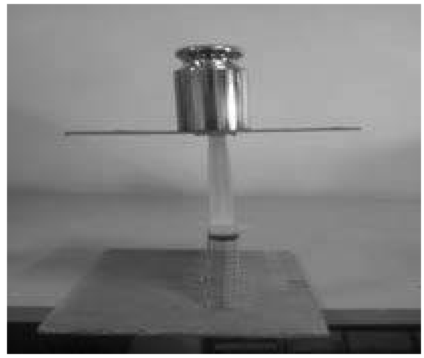
1. Fill the syringe with air by pulling the plunger. See to it that the volume reading is at approximately 25.0 mL.

2. Seal the opening of the syringe with the melted glue stick.

3. Bore a hole that is very close to the size of the opening of the syringe in a 6” by 4” flat wood. Screw the wood on a stable object. Insert in an upright position the sealed part of the syringe in the hole of the wood, be sure it is sturdy.

4. Paste a 5” by 3” illustration board at the end of the plunger. This will serve as the holder of the weights. You have just prepared a Boyle’s Law Apparatus.

5. Carefully place a 200-gram weight on the holder and get the volume reading.



6. Place one at a time different weights to the plunger.
   If you do not have set of weights, you may use books of the same kind. Be sure to get the mass of each book.

7. Record the mass and volume reading using Table 5.

Table 5. Observation on Volume Changes

Trial	Volume (cm^3)	Mass (g)	Pressure (N/m^2)
Initial Reading			
1			
2			
3			
4			
5			

Note: ***P*** = Force/Area
Force = mass (kg) x acceleration due to gravity ($9.8 m/s^2$)
πr^2 = Surface Area of the syringe

Q1. What happens to the volume of the syringe as the set of weights is added on top of it?

Q2. What happens to the pressure on the syringe when the set of weights is added?

8. Plot a graph with the pressure at the y axis and volume at the x axis.

Q3. Describe the graph.

Q4. What is the relationship between volume and pressure of gases at constant temperature?

The activity you have performed enables you to observe Boyle's Law, which can be used to describe the relationship between the volume and pressure of gases at constant temperature. Based on the result of your activity, what can you infer?

In your Grade 9 lesson on living things and their environment, you made use of the lung model to explain the respiratory system. Do you still have the model with you? Try to use it again. What do you notice as you pull the bigger balloon that represents the diaphragm? Yes, the lungs expand! Let's try to explain it with the use of Boyle's Law. Pulling the rubber balloon represents inhaling. As you inhale, the lung cavity expands, causing the pressure inside the lungs to decrease and become lower than the outside pressure. As a result, air flows from the higher pressure area, which is outside the body, into the lungs. Exhaling is the opposite process; when you release the rubber which represents the diaphragm, the balloon representing the lungs decreases in volume. This phenomenon happens during exhaling. When the diaphragm contracts as you exhale, it results to a decrease in the lung volume, increasing the pressure inside the chest cavity and causing air to flow out of the lungs. Try to breath in and breath out and mindfully observe what happens to your lung cavity. Interestingly, as you inhale and exhale, approximately 500 mL of air gets in and out of your lungs.

Here is another thing that can happen which can be explained through Boyle's Law. Have you observed the air exhaled by the fishes in the aquarium? It gets bigger and bigger as it rises because the pressure at the bottom of the aquarium is higher than the pressure near the surface.

Where else do you see applications of the relationship between pressure and volume of gases?

Robert Boyle (1627-1691)

> The relationship between the volume and pressure of gases at constant temperature was first stated by Robert Boyle during the 16th century. He performed an experiment wherein he trapped a fixed amount of air in the J-tube, he changed the pressure and controlled the temperature and then, he observed its effect to the volume of the air inside the J-tube. He found out that as the pressure is increased, the volume decreases. He finally concluded that the volume of a fixed amount of gas is inversely proportional to its pressure at constant temperature.

Similarly, this is what you observed when you perform Activity 2.

Gas particles have a very weak intermolecular force of attraction, hence they move as far as possible from each other. They have the tendency to occupy all the spaces they are contained in. If the pressure is increased, the volume will be decreased forcing the gas particles to move closer to one another.

The observations in Activity 2 can be expressed in the Boyle's Law equation:

$$\mathbf{V \ \alpha \ \frac{1}{P}} \quad \textbf{at constant T and n}$$

Where:
V = volume, P = pressure, T = temperature and n = amount of the gas.

How will you read the above sited equation? It is read as: The volume of a gas is inversely proportional to its pressure, if temperature and amount of a gas are held constant.

It can also be read as: At constant temperature, the volume occupied by a fixed amount of gas is directly proportional to the reciprocal of pressure (1/P).

Let's take a look at the equation again and try to change the proportionality sign (**α**) with the equal sign (=).

$$\mathbf{V} \;\; \alpha \;\; \frac{\mathbf{1}}{\mathbf{P}} \;\; \textbf{at constant (k)}$$

$$\mathbf{V} = \frac{\mathbf{k}}{\mathbf{P}} \;\; \textbf{Thus, k = VP}$$

The latter equation is simply read as:

The product of Pressure and Volume is constant.

What is the value of Vx P in Table 6?

Table 6. Data on Volume-Pressure Relationship

Trial	Volume (L)	Pressure (atm)	VxP
1	2.0	10.00	
2	4.0	5.00	
3	8.0	2.50	
4	16.0	1.25	

Were you able to verify the meaning of proportionality constant?

Let us apply the equation you learned about Boyle's Law. Since volume and pressure of the gas can be varied, let P_1 and V_1 be the initial pressure and volume respectively and P_2 and V_2 be the final pressure and volume respectively.

According to Boyle's Law, PV= k therefore:

$\mathbf{V_1P_1 = k}$
$\mathbf{V_2P_2 = k}$
then $\mathbf{V_1P_1 = V_2P_2}$

You are now equipped with the fundamental knowledge to cope with the problem solving activities related to Boyle's Law.

Let's try to solve this problem:

The inflated balloon that slipped from the hand of Renn has a volume of 0.50 L at sea level (1.0 atm) and it reached a height of approximately 8 km where the atmospheric pressure is approximately 0.33 atm. Assuming that the temperature is constant, compute for the final volume of the balloon.

Source: http://regentsprep.org/Regents/math/algtrig/ATP8b/exponentialResource.htm

In analyzing the problem, it is important that you categorize the initial and final conditions of the variables:

Initial Conditions	Final Conditions
V_1 = 0.50 L	V_2 = ?
P_1 = 1.0 atm	P_2 = 0.33 atm

By applying Boyle's Law, can you predict what will happen to the final volume?

Yes, you're right! The final volume will increase. Let's compute for the numerical value of the final volume by substituting the given values to this equation.

$$\mathbf{V_1P_1 = V_2P_2}$$

$$\mathbf{V_2 = V_1P_1 / P_2}$$

$$\mathbf{V_2 = \frac{(0.50\ L)\ (1.0\ atm)}{(0.33\ atm)} = 1.5\ L}$$

Did you notice the decrease in pressure and how it affects the final volume? The pressure decreased by 1/3. That is why, the volume increased by 3-folds. Try to multiply V_1 by P_1 and V_2 by P_2. Does it have the same product? Isn't it amazing?

Answer the following problems for a better grasp of the lesson:

1. Oxygen gas inside a 1.5 L gas tank has a pressure of 0.95 atm. Provided that the temperature remains constant, how much pressure is needed to reduce its volume by ½?

2. A scuba diver needs a diving tank in order to provide breathing gas while he is underwater. How much pressure is needed for 6.00 liters of gas at 1.01 atmospheric pressure to be compressed in a 3.00 liter cylinder ?

3. A sample of fluorine gas occupies a volume of 500 mL at 760 torr. Given that the temperature remains the same, calculate the pressure required to reduce its volume by 1/3.

You have shown good mastery of the concepts on Boyle's Law, thus you can now proceed to the next activity. This time, we will find out if there is a relationship between volume and temperature at constant pressure.

Activity 3

Charles' Law

Objective:

Investigate the relationship between volume and temperature at constant pressure.

Materials:

- rubber balloon
- tap water
- hot water
- ice
- thermometer
- alcohol lamp
- tape measure

Procedure:

1. Prepare 3 beakers (1 for ice water, 1 for tap water, and another one for hot water).

2. Inflate a balloon.

3. Measure the circumference of the balloon using a tape measure.

4. Get the temperature reading of the hot water.

5. Put the balloon in hot water for 2 minutes, then measure again its circumference.

6. Do three trials and get the average of the results.
7. Repeat procedures 3 to 6 using tap water.

8. Repeat procedures 3 to 6 . This time use ice water.

9. Record the results in the Table 7.

Table 7. Data on Determining the Size of the Balloon at Different Temperatures

Set-up	Average Temperature (°C)	Average Circumference of the Balloon (cm)		
		before	after	difference
Warm Water				
Tap Water				
Ice Water				

Q1. What happens to the size of the balloon as the temperature decreases?

Q2. How does the change in the temperature relate to the volume of gas in the balloon?

The learning experiences you have from Activity 3 focuses on the volume-temperature relationship. Can you enumerate familiar events you observe in your community and household which are related with the volume-temperature relationship in gases?

The sky lanterns we use in celebrating New Year, Christmas, weddings, and other important occasions operate on the concept of volume-temperature relationship. Have you tried releasing a sky lantern? It is like a mini-hot air balloon; as the temperature increases, the sky lantern obtains its full volume and rises in the atmosphere. It rises and rises as the temperature increases because the density of gases decreases as gases expand due to the increase in temperature. This explains that the increase in volume and decrease in density cause the sky lantern to float in the air!

Jacques Charles
(1746- 1823)

The volume - temperature relationship in gases (k = V/T) was determined by and named after Jacques Charles. In his experiment, Jacques Charles trapped a sample of gas in a cylinder with a movable piston in water bath at different temperatures. Jacques Charles found out that different gases decreased their volume by factors 1/273 per °C of cooling. With this rate of reduction, if gas will be cooled up to -273°C, it will have zero volume! Interesting, isn't it? Charles' Law states that at constant pressure, the volume of a fixed amount of gas is directly proportional to the Kelvin (K) temperature.

Mathematically, Charles' Law can be expressed as:

$$\mathbf{V \alpha T \text{ at constant } P}$$

Where: **V** = volume and
T = temperature expressed in Kelvin

Why is there a need to convert °C to K? Kelvin is the basic unit for measuring temperature in the International System (SI). "It denotes the absolute temperature scale whereby 0K or absolute zero is defined as the temperature when molecules will have the lowest energy."

Removing the proportionality symbol (α) and using the equality sign (=) the equation will be as follows:

$$V = kT \qquad \text{or} \qquad k = \frac{V}{T}$$

Thus, in a direct proportion, the quotient of the variable is constant.

If you are going to consider the initial and final conditions, you will arrive at the following equations:

$$\frac{V_1}{T_1} = k \qquad \text{and} \qquad \frac{V_2}{T_2} = k$$

Whereas, V_1 is the initial volume and V_2 is the final volume
T_1 is the initial temperature and T_2 is the final temperature

If the volume-temperature ratios are the same in the initial and final conditions, then we will arrive at this equation:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

To further illustrate the mathematical equations above, let us have the following:

A gas cylinder was measured to have different volumes at different temperature as shown in Table 8. Complete the table with the necessary information.

Table 8. Data on Volume-Temperature Relationship

Trial	Volume Reading (ml)	Temperature (°C)	Temperature (K)
1	25	2	
2	30	57	
3	35	102	
4	40	152	

Note: To convert **°C** to K, use this formula: **K = °C + 273.15**

Plot the data from Table 8 in a graph by placing the volume in the y axis and temperature at Kelvin scale in the x axis.

How is this graph different from the graph you obtained in Activity 2?

Let's apply Charles' Law in solving problems related to volume-temperature relationship in gases.

Sample Problem:

An inflated balloon with a volume of 0.75 L at 30°C was placed inside the freezer where the temperature is -10°C. Find out what will happen to the volume of the balloon if the pressure remains constant. Support your answer with computation.

Just like what we did before, let's start with the given variables:

Initial Conditions	Final Conditions
$V_1 = 0.75L$	$V_2 = ?$
$T_1 = 30°C = 303K$	$T_2 = -10°C = 263K$

Convert the temperature to Kelvin.

K = °C + 273 = 30 + 273 = 303K

Solve for the final volume.

$$V_2 = \frac{V_1 T_2}{T_1} = \frac{(0.75L)\ (263\cancel{K})}{303\cancel{K}} = \frac{197.25L}{303} = 0.65L$$

Were you able to predict it correctly? Try to divide V_1 by T_1 and V_2 by $T_{2.}$ Did you obtain the same quotient? Amazing!

The volume decreases because the temperature decreases too. In this case, the volume between the gas molecules decreases because the kinetic energy is also affected by temperature. Do you realize the relationship of Charles' Law to Kinetic Molecular Theory? Gas molecules move slowly at low temperature, thus there is less collision and so it will occupy smaller space.

Answer the following Charles' Law problem to facilitate mastery of concepts on the volume-temperature relationship:

1. A cylinder with a movable piston contains 250 cm^3 air at 10°C. If the pressure is kept constant, at what temperature would you expect the volume to be 150 cm^3?

2. A tank (not rigid) contains 2.3 L of helium gas at 25°C. What will be the volume of the tank after heating it and its content to 40°C temperature at constant pressure?

3. At 20°C, the volume of chlorine gas is 15 dm^3. Compute for the resulting volume if the temperature is adjusted to 318K provided that the pressure remains the same.

Aside from Boyle's and Charles' laws, there is another gas law that you need to be familiar with. Have you ever wondered how temperature affects the pressure of the gas at constant volume?

The next activity will help you visualize the effect of increasing the pressure on the temperature of gases at constant volume.

Activity 4

Gay-Lussac's Law

Objective:

Investigate the relationship between temperature and pressure at constant volume.

Materials:

- 110°C thermometer
- Erlenmeyer flask/bottle
- cork or rubber stopper
- denatured alcohol
- Liquid dropper

Procedure:

1. Insert the thermometer into the stopper. **Precaution: Lubricate the thermometer with a small amount of grease before insertion.**

2. Put 5 drops of denatured alcohol in the Erlenmeyer flask.

3. Cover the Erlenmeyer flask with the stopper that you prepared in Procedure 1. The size of the stopper should fit the mouth of the Erlenmeyer flask. Wait for 2 minutes before measuring the temperature.

4. Shake the Erlenmeyer flask for 2 minutes and take the temperature reading.

CAUTION: Carefully hold the thermometer to avoid breakage.

5. Perform three trials and record the data.

Table 9. Data on Temperature of the Gas Before and After Shaking the Erlenmeyer flask

Trial	Temperature (C^o)	
	Before Shaking	**After Shaking**
1		
2		
3		
Average		

Q1. What happens to the drops of denatured alcohol after 2 minutes? after another 2 minutes ?

Q2. Compare the pressure exerted by the denatured alcohol molecules before and after shaking?

Q3. How is the temperature of gas molecules affected by pressure or vice versa?

The previous activity revealed to us the temperature-pressure relationship at constant volume in gases. Can you think of some phenomena which can be explained by this relationship? Are you familiar with the pressure cooker? The pressure cooker is airtight, so pressure builds up inside the pressure cooker as the liquid inside comes to a boil. The resulting trapped steam causes the internal temperature to rise more than what it can normally do at normal atmospheric pressure. Thus, the cooking of hard meat and fibre is done at a short period of time.

The person who is credited with the determination of the temperature-pressure relationship in gases at constant volume is Joseph Louis Gay-Lussac. He deduced that the pressure of the gas is directly proportional to its temperature.

Joseph Louis Gay-Lussac (1746- 1823)

This means that when the temperature of gases increases its pressure also increases or vice versa. Hence, we can state the Gay-Lussac's Law as: At constant volume, the pressure of a fixed mass of gas is directly proportional to the absolute temperature.

Gay-Lussac's Law can be expressed mathematically as

$$P \propto T \text{ at constant Volume}$$

It is can be written as:

$$P = kT \quad \text{or} \quad k = \frac{P}{T}$$

Since there is a direct proportionality between the pressure and temperature of gases at constant volume, it can be shown in this equation:

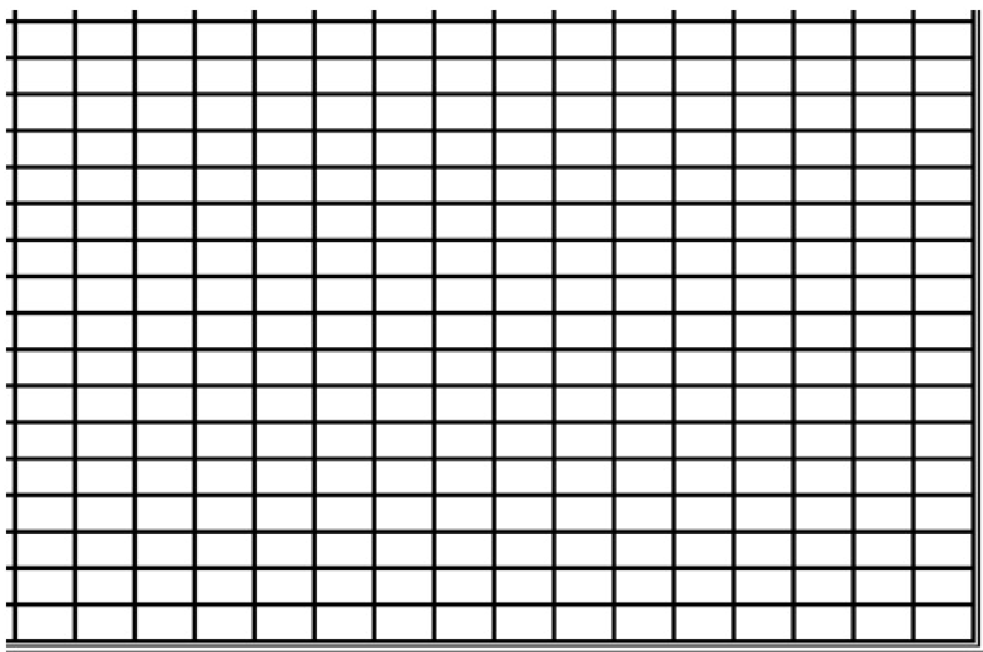
$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Consider this table:

Table 10. Data on Temperature-Pressure Relationship of Gases

Trial	Pressure (atm)	Temperature (K)	P/T
1	1.0	100	
2	2.0	200	
3	3.0	300	
4	4.0	400	

Plot a Temperature-Pressure graph using the data in the Table 10.



What kind of relationship is depicted in the graph?

Let us apply Gay-Lussac’s Law in problem solving:

Sample Problem: The pressure of a nitrogen gas inside a rigid tank is 1.5 atmosphere at 30°C. What will be the resulting pressure if the tank is cooled to 0°C?

Identify the given:

Initial Conditions	Final Conditions
P_1 = 1.50 atm	P_2 = ?
T_1 = 30^{o}C = 303	T_2 = 0^{o}C = 273K

Convert the temperature to Kelvin.

$K = °C + 273$
$K = 30° + 273 = 303K$

Then substitute the given values to this equation.

$$P_1 / T_1 = P_2 / T_2$$

$$P_2 = P_1 T_2 / T_1$$

$$P_2 = (1.50\ \cancel{atm})\ (273\ \cancel{K})\ /\ 303\ K = \mathbf{1.35\ atm}$$

Were you able to determine correctly that there will be a decrease in the pressure of nitrogen gas? That's the beauty of understanding the relationship between temperature and pressure of gases.

Practice makes perfect! Answer the following problems on Gay-Lussac's Law to ensure mastery of concepts on the temperature-pressure relationship:

1. A certain light bulb containing argon has a pressure of 1.20 atm at 18°C. If it will be heated to 85°C at constant volume, what will be the resulting pressure? Is it enough to cause sudden breakage of the bulb?

2. At 20°C a confined ammonia gas has a pressure of 2.50 atm. At what temperature would its pressure be equal to 760 mmHg?

3. The helium tank has a pressure of 650 torr at 25°C. What will be the pressure if the temperature is tripled?

You have demonstrated pretty well your skills in problem solving. Good job!

Let's have a review:

Table 11. Gas Laws' Working Formula

Gas Law	Working Formula
Boyle's Law	$V_1P_1 = V_2P_2$
Charles' Law	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$
Gay-Lussac's Law	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

The above cited laws show the relationship of two variables in gases. In the next activity, you will observe the interrelationship among the three variables of gases as to volume, temperature, and pressure.

Activity 5

Combined Gas Laws

Objective:

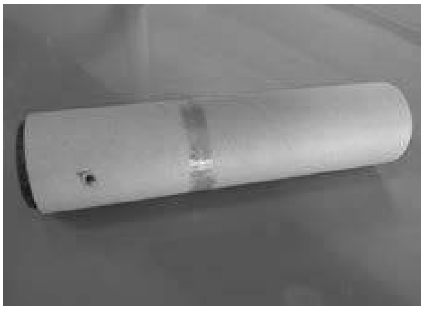
Determine the relationship among temperature, pressure, and volume of gases at constant number of moles.

Materials:

- liquid dropper
- cylindrical container with cover
- denatured alcohol
- match/candle
- ruler

Procedure:

1. Get a cylindrical container made of hard carton and bore a hole near its bottom.



2. Remove the cover of the cylindrical container and put 5 drops of denatured alcohol. **Caution: Denatured alcohol is toxic or poisonous. It can cause blindness. BE CAREFUL!**
3. Cover and hold the cylindrical container in such a way that your thumb is covering the hole near the base.

4. Shake the container vigorously for 1 minute.

5. Place the container on the table or arm rest. As quickly as possible, place a lighted match/candle near the hole. Observe what will happen. **Cautions: The container of the denatured alcohol should be placed as far as possible from your working area because it is flammable. Immediately wash your hands with plenty of water after this procedure.**

Q1. What happens to the cylindrical container when a source of heat is placed near the hole?
Q2. Why do you need to shake the container after putting 5 drops of denatured alcohol?
Q3. How is the volume of the gases related to its temperature and pressure?

Can you think of applications involving combined gas law?

The weather balloon which carries instruments upward to be able to send back information on atmospheric pressure, humidity, temperature, and wind speed through radiosonde also applies Combined Gas Law. As the weather balloon rises up from the ground, it responds to three variable changes in the surroundings; volume, pressure, and temperature.

Have you ever notice the warning label in the aerosol container? What is the temperature requirement for its storage? Have you seen an explosion of a can of this kind? The explosion of this container is also an application of Combined Gas Law."The exposure to high temperature increases the kinetic energy of the gases causing an increase in the pressure due to the increased collision of the gases on the walls. An increase in pressure would result in expansion of volume. But because the can is contained, thus the container explodes."

No one is credited for the Combined Gas Law. Putting together Boyle's Law and Charles' Law together will result to this statement.

The pressure and volume of a gas are inversely proportional to each other, but are both directly proportional to the temperature of that gas.

Translating it to mathematical equation will give us the following:

$$T = \frac{VP}{K} \quad \text{or} \quad V = \frac{kT}{P} \quad \text{or} \quad P = \frac{kT}{V} \quad \text{or} \quad k = \frac{PV}{T}$$

The constant k in the equation above is known as the universal gas constant. It is the result of the combination of the proportionality constants in the three gas laws. Note that the formula is equal to a constant, thus it is possible to compute for the change in volume, temperature, or pressure using the following proportion:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Let's use the Combined Gas Law in determining change in the final volume, temperature, or pressure of gases.

Sample Problem: The oxygen tank manufacturer used to produce 5.0 L oxygen tanks at 2000 psi and 25°C . Statistics suggests that the 3.0 L oxygen tank at 1500 psi more marketable. What temperature requirement is needed to produce a 3 L oxygen tank at 1500 psi?

The given values are:

Initial Conditions	**Final Conditions**
V_1 = 5.0 L	V_2 = 3.0 L
T_1 = 25^{o}C = 298K	T_2 = ?
P_1 = 2000psi	P_2 = 1500 psi

Computing for temperature requirement:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$T_2 = \frac{T_1P_2V_2}{P_1V_1}$$

$$T_2 = \frac{(298K)\ ((1500\cancel{psi})\ (3.0\cancel{L})}{(2000\cancel{psi})\ (5.0\cancel{L})}$$

T_2 = 134K ≈ 130 K

Answer the following problems:

1. Helium gas has a volume of 250 mL at 0°C at 1.0 atm. What will be the final pressure if the volume is reduced to 100 mL at 45°C?

2. The volume of a gas at 27°C and 700.0 mmHg is 600.0 mL. What is the volume of the gas at -20.0°C and 500.0 mmHg?

3. A 2.5 L of nitrogen gas exerts a pressure of 760 mmHg at 473 K. What temperature is needed to reduce the volume to 1.75 L at 1140 torr?

It is really important to know how the properties of gases affect us and our environment. There is a lot more as you move on to the next activities.

Do you still remember the mole concept? Can you still recall what a mole means? The number of moles quantifies the amount of a substance. What could be the possible relationship of the amount of gas in a mole to its volume? Can you make a prediction about it?

Amedeo Avogadro
(1776-1856)

During the first half of the nineteenth century, Lorenzo Romano Amedeo Carlo Avogadro, Count of Quaregna and Cerreto, made important contributions in shedding light on reaction stoichiometry. He provided explanations as to why compounds reacted in definite ratios and on how the amount of gas affects its volume. Experimentally, the most convenient way of quantifying the amount of gas is through its mass. Avogadro played an important role in providing evidence of the existence of atoms. Eventually the number of molecules in a mole is named after him.

In 1811, Avogadro wrote in a paper that, "Equal volumes of all gases, kept at the same pressure and temperature, contain the same number of molecules." Avogadro was the first to suggest that the volume of a gas is directly proportional to the number of moles of gas present at a given temperature and pressure.

If the volume of gases is directly proportional to the number of mole whose symbol is n, what will be the mathematical equation for the volume-mole relationship? Can you still recall the way we represent the relationship in a mathematical equation?

Using the proportionality symbol, we can express the proportionality between the volume and the number of mole of a gas as:

V α n at constant T and P

Mathematically, the Avogadro's Hypothesis can be expressed as:

$$\frac{\mathbf{V}}{\mathbf{n}} = \boldsymbol{k}$$

where V is the volume of gas
n is the amount of gas in moles and
k is a proportionality constant

This can also be expressed as:

$$\frac{V_1}{n_1} = \frac{V_2}{n_2} \quad \text{or} \quad V_1n_2 = V_2n_1$$

Let's have this table:

Table 12. Data on Avogadro's Hypothesis

Volume (L)	No. of moles (mol)	V/n (L/mol)
2.50	0.50	
5.00	1.0	
7.50	1.5	
10.00	2.0	
12.50	2.5	

Did you obtain a constant value for V/n ?

Predict how the Volume-Mole graph would look like. Verify your prediction, plot a graph.

Let's apply Avogadro's Hypothesis in solving this problem.

What will be the final volume of a 5.00 L He gas which contains 0.965 mole of at 30°C and 1.00 atmosphere, if the amount of this gas is increased to 1.80 moles provided that temperature and pressure remains unchanged?

As we have done in the past lessons, let's start analysing the problem by identifying the initial and final conditions:

Initial Conditions	**Final Conditions**
V_1 = 5.0 L	V_2 = ?
n_1 = 0.965 mol	n_2 = 1.80 mol
P_1 = 1.00atm	P_2 = 1.00atm
T_1 = 30^{o}C	T_2 = 30^{o}C

Since the temperature and pressure are held constant, we will use this formula:

$$V_2 = \frac{V_1 n_2}{n_1}$$

$$= \frac{(5.0L)\ (1.80\cancel{mol})}{0.965\ \cancel{mol}} = 9.3L$$

Let's have more problem sets!

1. A 7.25 L sample of nitrogen gas is determined to contain 0.75 mole of nitrogen. How many moles of nitrogen gas would there be in a 20 L sample provided the temperature and pressure remains the same.

2. Consider the following chemical equation:

$2NO_2$ (g) N_2O_4 (g)

If 50.0 mL of NO_2 gas is completely converted to N_2O_4 gas, under the same conditions, what volume will the N_2O_4 occupy?

Can we observe Avogadro's Hypothesis in real life scenarios?

Try to observe the baking of bread or cake at the nearest bakery in your place. How can you explain the phenomenon of having a bigger bread or cake compared with the dough?

Can you also use this law to explain the production of balloons and the way vulcanizing shop deals with flat tires?

Activity 6

Squashing the Bottle

Adopted from Apex

Objective:

Show the relationship among volume, temperature, pressure and number of moles.

Materials:

- two empty, plastic, 1.5-litre bottles with cover
- hot water
- ice cubes
- hammer
- plastic bag

Procedure for Activity A:

1. Fill one-third of the bottle with hot water.

2. After a few seconds, empty the bottle and put the cover at once.

   Q1. What happened when you covered the bottle?

   Q2. What caused it to happen?

Procedure for Activity B:

1. Put some ice cubes in a plastic bag. Crush the cubes with a hammer.

2. Put the crushed ice cubes in the bottle. Put the cover on.

3. Shake the bottle so that the inner portion is thoroughly chilled. Observe the bottle.

   Q4. What happened to the bottle?

   Q5. Explain the phenomenon.

Let's us now recall the previous gas laws that we have learned in this module.

The different gas laws are:

Boyle's Law: $V \alpha \frac{1}{P}$ *(n and T are constant)*

Charles' Law: $V \alpha T$ *(n and P are constant)*

Avogadro's Law: $V \alpha n$ *(P and T are constant)*

Combining the three laws, you will get:

$$V \alpha = \frac{nT}{P}$$

Using the sign of equality will result to this equation:

$$V = \frac{RnT}{P} \quad \text{or} \quad PV = nRT$$

where:

V = volume in liters
P = pressure in atmosphere
n = moles
T = temperature in Kelvin
R = universal gas constant, $\frac{0.0821 \text{ L. atm}}{\text{mol. K}}$

Do you have an idea on how we arrived at the value of proportionality constant (R)?

Based on the equation above, can you state the ideal gas law in your own words?

The Ideal Gas Equation is useful in illustrating the relationship among the pressure, volume, temperature, and number of moles of a gas. This equation is used to describe gases that behave ideally.

Do gases behave ideally? Discuss among your group members and prove your answer. Validate your answer by consulting Science Teachers, reading books, and internet search to name a few.

Let's apply the ideal gas law equation in this problem:

> What is the volume of a container that can hold 0.50 mole of gas at 25.0°C and 1.25atm?

The given are:

Pressure: 1.25 atm
Temperature: 25.0°C + 273 = 298 K
No. of moles: 0.50 mole

We are asked to calculate for the volume so let's substitute the given values to this equation:

$$PV = nRT$$

$$V = \frac{nRT}{P}$$

$$= \frac{(0.50\ \cancel{mole})\ (0.0821\ L\ \cancel{atm}/\cancel{mol}.\ \cancel{K})\ (298\cancel{K})}{1.25\ \cancel{atm}}$$

$$= 9.8L$$

Let's use the ideal gas equation in the following problems:

1. Calculate the pressure exerted by a 0.25 mole sulfur hexafluoride in a steel vessel having a capacity of 1250 mL at 70.0°C.
2. Fermentation of glucose produce gas in the form of carbon dioxide, how many moles of carbon dioxide is produced if 0.78 L of carbon dioxide at 20.1°C and 1.00 atm was collected during the process?
3. A sample of liquid acetone is placed in a 25.0 mL flask and vaporized by the heating to 75°C at 1.02 atm. The vapor weighs 5.87 g. Calculate the number of moles of the acetone.

Having enough information about the behaviour of gases you are now ready to explain the Kinetic Molecular Theory.

Activity 7

A Gaseous Outlook

Adopted from Apex

Objective:

Determine the application of gas laws in daily occurrences.

Materials:

Activity A
- string
- sticky tape
- medium-sized balloon
- drinking straw

Activity B
- glass bottle
- medium-sized balloon
- sink with hot and cold water

Activity C
- bowl
- drinking glass
- water

A. Jet-Propelled Balloon

1. Thread a string through the straw and tie its ends tightly between two points at equal heights in a room (e.g., handles or hooks).
2. Inflate the balloon and keep the neck closed between your fingers.
3. Fix the balloon underneath the drinking straw with the sticky tape and pull the balloon along to one end of the string.
4. Pull your fingers against the mouth of the balloon then let go.

Q1. Explain why the balloon shoots along the thread at a speed using the concept of the gas laws.

Q2. What does this prove regarding the compressibility of gases?

B. The Rising Water

1. Put the glass into the water upside down.

2. Lift the glass up, but without the rim going above the surface of the water. Observe what happens.

Q1. What happened to the level of the water inside the glass?

Q2. What caused this to happen?

Q3. If the rim of the glass was raised above the surface of the water what might have happened?

Let us try to make ourselves familiar with the Kinetic Molecular Theory and try to relate the above mentioned concepts with the said theory.

Kinetic Molecular Theory states that:

a. Gases are composed of molecules. The distances from one molecule to another molecule are far greater than the molecules' dimensions. These molecules can be considered as spherical bodies which possess negligible mass and volume.

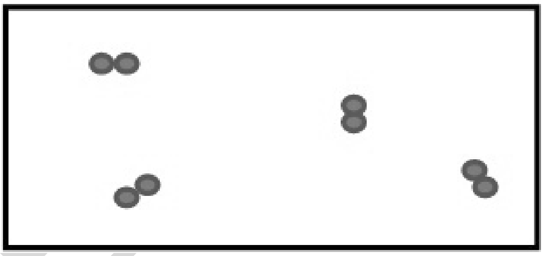


Figure 1. Molecules of Gases

b. Gas molecules are always in constant random motion and they frequently collide with one another and with the walls of the container. Collision among molecules are perfectly elastic, that is, energy may transfer from molecule to molecule as the result of collision but the total energy of all the molecules in the system remains the same/constant.

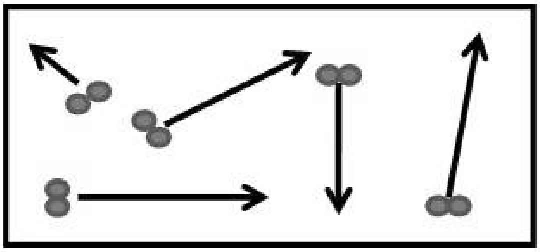
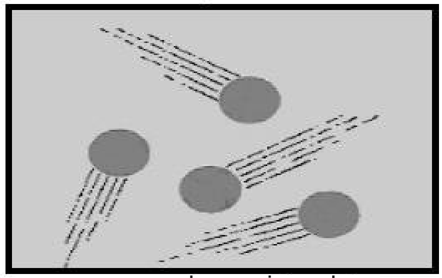


Figure 2. Molecules of Gases in Random Motion

c. There is a neither attractive nor repulsive force between or among gas molecules.

d. Movement of gas molecules is affected by temperature. The average kinetic of the molecules is directly related to the temperature of gas.



www.chem.wisc.ed

The Kinetic Molecular Theory (KMT) explains the properties of gases and describes the behavior of gases. You can relate the early discussions that we had with this theory.

So far, you have learned that gases have mass, volume, temperature and it exerts pressure. The pressure exerted by gas molecules is due to collision among gas molecules and with the walls of the container. The frequency of collision is affected by temperature because gas molecules move faster at high temperature, on the other hand, they move slowly at low temperature. The faster the movement of the molecules, the more frequent the collision, causing an increase in pressure.

Let's check whether you understand the Kinetic Molecular Theory. Try to answer the following:

Direction: Identify and underline the possible weakness or flaws in the postulates. Write TRUE if the postulate is accurate and FALSE if the postulate is flawed.

Postulates

1. A gas consists of a collection of small particles traveling in straight line motion and obeying Newton's Laws.

2. The molecules in a gas occupy negligible volume.

3. Collisions between molecules are perfectly elastic (that is, no energy is gained nor lost during the collision).

4. There are negligible, attractive, or repulsive forces between molecules.

5. The average kinetic energy of a molecule is constant.

Lifted from "Applied Academics for Excellence" (APEX)

IV. Summary/Synthesis/Feedback

- Gas is one of the phases of matter. It has no definite shape and size. It can be compressed easily.
- Properties of gases include mass, volume, temperature, and pressure.
    - The amount of a gas or its mass could be expressed in moles or grams. The mass of gases is negligible.
    - The volume of a gas is the amount of space occupied by the gases. Gases have the tendency to occupy all the spaces of the container that they are confined. They have weak intermolecular force of attraction; hence they are arranged as far away as possible from each other. The common units used in expressing the volume of a gas are liter (L) and milliliter (mL).
    - The temperature of a gas is the measure of the hotness or coldness of an object. It is proportional to the average kinetic energy of its molecules. It can be measured in Celsius or Kelvin. Kelvin is the absolute scale.
    - The pressure of a confined gas is the average effect of the forces of the colliding molecules. It can be measured in atmosphere, torr, psi, cmHg or mmHg. It can be quantified using this equation:

      $P = F/A$
      Where: P= pressure, F = force, and A= area

      $F = ma$
      Where: F = force, m = mass and a = acceleration

- The properties of gases can affect one another. They are related to each other.
    - The volume of a gas is directly related to its temperature at constant pressure.
    - The pressure of a gas is directly related to its temperature at constant temperature.
    - The volume of a gas is inversely related to its pressure at constant temperature.

- The amount of a gas in a mole is directly related to its volume at constant pressure and temperature.

- The properties of gases can be varied. The relationships of these properties can be quantified experimentally with the aid of the different laboratory apparatus or by using the different gas laws as follows:

  - Boyle's Law $V_1P_1 = V_2P_2$
  - Charles' Law $V_1 / T_1 = V_2 / T_2$
  - Gay-Lussac's Law $P_1 / T_1 = P_2 / T_2$
  - Avogadro's Law $V_1n_2 = V_2n_1$
  - Combined Gas Law $V_1P_1 T_2 = V_2P_2 T_1$
  - Ideal Gas Law $PV=nRT$

  Where V= volume,
  P = pressure,
  T = temperature,
  n = amount of gas in moles
  R = 0.0821 L.atm./mol.K
  1= used as a subscript,means initial condition
  2= used as a subscript,means final condition

- Not all gases behave ideally. Most of the gases found in nature conform to the principles of Boyle's Law, Charles' Law, Gay-Lussac's Law, Avogadro's Law, and Combined Gas Law.

- The following conversion factors are useful in solving gas law related problems:

  α. For volume
  1 mL = 1 cm^3 1 L = 1 dm^3 1 m^3 = 1000 L

  http://www.metric-conversions.org/volume/cubic-meters-to-liters.htm

  β. For pressure
  1 atm = 760 mmHg = 76 cmHg = 760 torr = 101,325 Pa = 14.6956 psi

  χ. For temperature

  0˚C = 273.15K 0˚C = 32 ˚F

- The behavior of the gas molecules can be explained by the Kinetic Molecular Theory. It states that:

    a. Gases are composed of molecules. The distances from molecule to molecule are far greater than the molecules' dimensions. These molecules can be considered as spherical bodies which possess negligible mass and volume

    b. Gas molecules are always in constant random motion and they frequently collide with each other and with the walls of the container. Collisions among molecules are perfectly elastic, that is, energy may transfer from molecule to molecule as the result of collision, but the total energy of all the molecules in the system remains the same/constant.

    c. There is a negligible attractive or repulsive force between or among gas molecules.

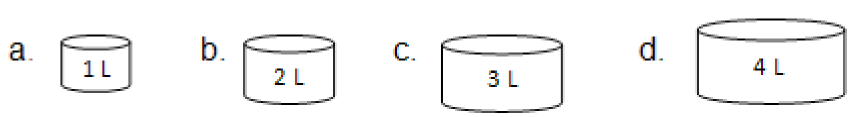
    d. Movement of gas molecules is affected by temperature. The average kinetic of the molecules is directly related to the temperature of gas.

V. Summative Assessment

1. Jane can still pump air in the party balloon even though it is already inflated. What explains this phenomenon?
    a. balloons look better if its size is bigger
    b. balloons are made up of plastic
    c. the air inside the balloon is hot
    d. air molecules can be compressed

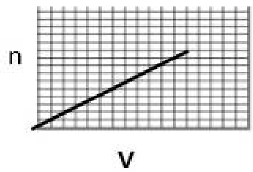
2. What is most likely to happen when an aerosol can is heated?
    a. the can will be deformed
    b. the can will stay the same
    c. the can will eventually explode
    d. the can will tarnish

3. Each container with varying volume has 1.0 mole of oxygen gas at 30.0°C. In which container will pressure be the lowest?

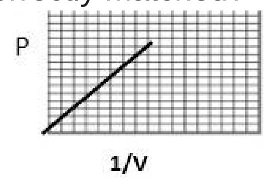


4. Which of the following phenomena best illustrates Charles' Law?
    a. carbon dioxide being dissolved in water
    b. expansion of the balloon as it is being submerged in hot water
    c. breathing apparatus being used by a patient
    d. leavening agent causing the fluffiness of cake products

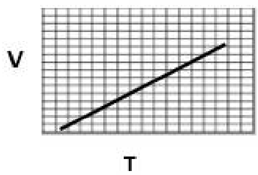
5. Which of the following pair/s is/are correctly matched?



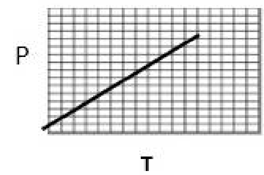
I. Avogadro's Law



II. Boyle's Law



III. Charles' Law



IV. Gay Lussac's Law

a. I & II b. III & IV c. I, III, & IV d. I, II, III, & IV

6. Which of the following samples is highly compressible at high pressure and expandable at high temperature?
   a. oxygen gas b. aluminium sheet c. water d. ice

7. Records show that the incident of tire explosion is high during summer season. Which of the following gives the best explanation for this observation?
   a. there are more travellers during summer vacation
   b. high temperature during summer season causes the air inside the tire to expand
   c. vehicles' tires are not well maintained
   d. there is too much air inside the tires

8. Which is most likely to happen when a closed vessel filled with gas is shaken for 2 minutes?
   a. the temperature inside the vessel increases
   b. the pressure inside the vessel increase
   c. the temperature and pressure inside the vessel increase
   d. both the temperature and pressure inside the vessel increase

9. Determine what will happen to the temperature of a confined gas as the pressure decreases.
   a. the gas temperature stays the same
   b. the gas temperature decreases
   c. the gas temperature increases
   d. there is no enough data

10. Gab wants to have a portable oxygen tank. A 5.00 liter oxygen gas exerts a pressure of 1.00 atmosphere. How much pressure is needed for this gas to be compressed in a 2.00 liter cylinder, provided there is no temperature change?
   a. 3.0 atm b. 2.5 atm c. 2.0 atm d. 1.5 atm

11. The temperature of nitrogen gas contained in a not rigid vessel is reduced from 100°C to 5.0°C? Which of the following describes the resulting behavior of nitrogen gas molecules?
    I. The average kinetic energy suddenly increases, thus the pressure increases
    II. The average kinetic energy suddenly decreases, thus the pressure decreases
    III. The volume occupied by the gas molecules suddenly increases, thus the container expand
    IV. The volume occupied by the gas molecules suddenly decreases, thus the container shrink

    a. I & III   b. II & IV   c. I & IV   d. II & II

12. A balloon with a volume of 200 mL at 30°C is submerged in hot water to obtain a temperature of 50°C. Find out what will happen to the volume of the balloon, provided the pressure remains the same.
    a. the volume of the balloon will become higher than 200 mL
    b. the volume of the balloon will become lower than 200 mL
    c. the volume of the balloon will stay the same
    d. there is no enough data

13. A 2.0 g (approximately 0.045 mole) sample of dry ice (solid carbon dioxide) is placed in an evacuated 3.5 L vessel at 30°C. Compute for the pressure inside the vessel after all the dry ice has been converted to carbon dioxide gas. (R=0.0821 L. atm/mol.K)
    a. 0.32 atm   b. 0.45 atm   c. 0.67 atm   d. 1.0 atm

14. What is the explanation to your answer in item number 13?
    a. the gaseous form of dry ice exerts the same pressure with its environment because it adopts the atmospheric pressure
    b. the gaseous form of dry ice exerts lower pressure due to the bigger volume that results to lesser collisions of the gas particles.
    c. the gaseous form of dry ice will have the same pressure because its composition remains the same
    d. the gaseous form of dry ice will either have high or low pressure

15. What do you expect to happen to the volume of a gas if its pressure is doubled and its temperature is reduced to half?
    a. its volume is increased
    b. its volume is doubled
    c. its volume remains unchanged
    d. its volume is decreased

References and Links

Printed Materials:

Briones, L.L., Templora, V. F., Tibajares, I. S. Jr. (2010). *Chemistry Power Science and Technology III,* vol.2, Manila: St. Mary's Publishing Corp.

Chang, R. (1998). *Chemistry*, 6th ed.,Boston:Mc.Graw-Hill

Davis, R. E., Sarquis, M., Frey, R., Sarquis, J. L., (2009). *Modern Chemistry. Teacher's Ed*., Orlando: Holt , Rinehart and Winston

LeMay, E.H. Jr., Robblee, K.M., Brower, H., Brower D.C., Beall H. (2000). *Chemistry Connections to Our Changing World*. 2nd ed., New Jersey: Prentice Hall, Inc.

Electronic Sources:

http://chemteacher.chemeddl.org/services/chemteacher/index.php?option=com_content&view=article&id=9

http://www.chm.davidson.edu/vce/GasLaws/AvogadrosLaw.html

http://www.grc.nasa.gov/WWW/K-12/airplane/Animation/frglab2.html

http://phet.colorado.edu/simulations/sims.php?sim=Gas_Properties

http://www.mhhe.com/physsci/chemistry/essentialchemistry/flash/gasesv6.swf

http://intro.chem.okstate.edu/1314F00/Laboratory/GLP.htm

http://preparatorychemistry.com/Bishop_animations.htm

http://www.chemistry.co.nz/avogadro.htm

http://www.chemteam.info/GasLaw/Gas-Avogadro.html

https://www.khanacademy.org/science/chemistry/ideal-gas-laws/v/ideal-gas-equation--pv-nrt

http://www.articlesbase.com/k-12-education-articles/avogadros-law-problems-with-solutions-6621701.html

http://www.chm.davidson.edu/vce/GasLaws/GasConstant.html

http://www.britannica.com/EBchecked/topic/475388/pressure

http://wps.prenhall.com/wps/media/objects/602/616516/Chapter_09.html

http://www.aiche.org/sbe/conferences/international-conference-biololecular-engineering-icbe/2013/events/experimental-computational-tools-engineering-biomolecules

https://encryptedtbn0.gstatic.com/images?q=tbn:ANd9GcTXN5x_t_qB2uvF19bKgYvegm1_bLTRKOr9CShmeSb5LRWyuJiu

Photos by: Francis E.Ansing and Ma. Victoria G. Senase

Suggested time allotment: 12 hours

Unit 4
MODULE
2

CHEMICAL REACTION

I. Introduction

From the time we get up in the morning to the time that we sleep at night, chemical changes are taking place, within us and outside of us. Plants grow through photosynthesis, foods that we eat are digested by the body, metals corrode, raw materials are being converted to useful products, new medicines are being developed, more versatile and cost effective materials are being made.

Various chemical changes that occur around us have significant effects to our environment and consequently to our health. Chemical changes occurring in industries result to products that are useful to us. The wastes we throw continue to undergo chemical changes and this has an impact on our well-being as well. The irresponsible use of fertilizers, herbicides and pesticides have negatively affected plants and aquatic life. We continue to pollute the atmosphere with vehicle and industrial gas emissions.

In your lower grade levels, you were exposed to some chemical reactions, you've tested the reactivity of some metals and you've seen the color changes of an indicator when tested with acids and bases. You have also learned in chemical bonding, that atoms gain stability by losing or gaining electron/s.

In this module , you will further understand how a chemical change proceeds, how bonds are broken and new bonds are formed, and how chemical reactions are translated into chemical equations, where rearrangements of atoms causes the formation of new substance/s. A lot of these chemical changes made the quality of our lives better.

This module contains the following lessons and activities:

1. Identifying chemical change
   Evidences of chemical reactions
   Chemical equation
2. Types of chemical reactions
3. Law of conservation of mass
4. Factors affecting reaction rate

How do chemical reactions take place?
What is the significance of studying the rates of reaction?

II. Learning Competencies/Objectives

The learner should be able to:

1. Write chemical equations;
2. Apply the principles of conservation of mass to chemical reactions;
3. Classify reactions according to the different types;
4. Identify the factors that affect reaction rates and explain them according to collision theory; and
5. Explain how the factors affecting rates of chemical reactions are applied in food preservation and materials production, fire control, pollution, and corrosion.

III. Pre-Assessment

1 -5 Multiple Choice. Choose the correct answer.

1. During a chemical reaction,
   a. atoms are destroyed
   b. atoms are rearranged
   c. elements are destroyed
   d. new elements are produced

2. A chemical reaction is a process in which
   a. all reactants change state
   b. products change into reactants
   c. the law of conservation of mass applies
   d. all of these

3. What determines an atom's ability to undergo chemical reactions?
   a. protons
   b. neutrons
   c. innermost electrons
   d. outermost electrons

4. How is a chemical equation is balanced?
   a. changing subscripts
   b. erasing elements as necessary
   c. adding coefficients
   d. adding elements as necessary

5. What are the products in the equation below?
   $Zn + CuSO_4$ -----> $ZnSO_4 + Cu$
   a. Zn and Cu
   b. Zn and $CuSO_4$
   c. $ZnSO_4$ and Cu
   d. Zn only

6 -10 Write true if the statement is correct and false if incorrect, and change the underlined word/s to make the statement correct.

6. Generally, the higher the concentration of the reacting substances, the faster is the reaction.
7. At lower temperature, chemical reactions occur at slower rates.
8. The bigger the surface area of the reactants, the faster the rate of reaction.
9. Catalysts increase the rate of reaction by providing a reaction pathway with a higher activation energy.
10. The minimum energy required to start a reaction is called bond energy.

11 - 12 Balance the following chemical equations, then classify the reaction according to its type

	Chemical Equation	Type of Reaction
11.	$CaCO_3$ = HCI ---> $CaCI_2 + H_2CO_3$	
12.	$AqNO_3$ = Zn ---> Zn $(NO_3)_2$ + Ag	

13-15 Explain in concise and brief sentences.

13. What is the function of MnO_2 in the production of oxygen from hydrogen peroxide in this reaction:

$$H_2O_2 \xrightarrow[MnO_2]{} H_2O + O_2$$

14. Why would iron fillings rust faster than an iron nail?

15. Enzymes are in molds and bacteria that spoil food. Explain, using your knowledge of factors affecting the rate of reaction, why food doesn't spoil as fast when it is refrigerated as it would at room temperature.

IV. Reading Resources and Instructional Activities

How do you know if a certain change that has taken place involves a chemical reaction? What indicators/ evidences should be present to consider it a chemical reaction?

Activity 1 will help you identify those indicators/evidences of chemical reactions.

Activity 1

Everything has changed

Objectives:

- Perform a laboratory activity involving chemical reactions;
- Distinguish evidences of chemical reactions.

Materials:

- Mg ribbon (Mg)
- Iron nail (Fe)
- 30 volumes Agua oxigenada
- Hydrogen peroxide (H_2O_2)
- Manganese dioxide (MnO_2)
- 10% copper sulfate ($CuSO_4$) solution
- 10% sodium hydroxide (NaOH) solution
- Denatured alcohol
- Vinegar
- Baking soda
- Matches
- Alcohol lamp
- Tripod
- Crucible tong
- Beakers or small transparent bottles
- Test tubes
- Test tube rack
- Thermometer
- Forceps or crucible tong
- Iron nail/shoe tack
- spatula or small teaspoon

Precautions

1. Wear goggles.
2. Be careful with the use of matches.
3. Do not touch substances, it may cause skin irritation.

Procedure A. Iron Nail-Copper Sulfate Reaction

1. Fill a test tube with 10 mL of copper sulfate solution.
2. Drop the nail gently into the solution.
3. Place the test tube in the test tube rack for a few minutes.

(You may proceed to the next procedure while waiting for any change.)

Table 1. Iron Nail-Copper Sulfate Reaction

Materials	Color Before Mixing	Color After Mixing
Copper solution		
Nail		

Q1. What happened to the color of the copper sulfate solution?

Q2. What happened to the color of the nail?

Procedure B. Magnesium Ribbon Reaction

1. Cut about 10 cm of magnesium ribbon.
2. Light the alcohol lamp.
3. Hold the magnesium ribbon with a crucible tong or forceps.
4. Place the magnesium ribbon over the flame.

Q3. What happened to the magnesium ribbon when you directly burned it?

Q4. What substance in the air could have reacted with magnesium during burning?

Q5. Describe the appearance of the product formed.

Table 2. Magnesium Ribbon Reaction

Materials	Before Burning		During Burning	
	Color	Appearance	Color	Appearance
Magnesium				

Procedure C. Hydrogen Peroxide (Agua Oxigenada) Reaction

This procedure should be done fast.

1. Pour 20 mL of agua oxigenada in a small beaker.
2. Using a spatula add a pinch of manganese dioxide (MnO_2) to the beaker.

Q6. What happened to the mixture?

3. Place a lighted match on top of the beaker near the bubbles. (Figure 1)
4. Observe what happens to the flame.

Q7. Describe the change you observe in the flame.

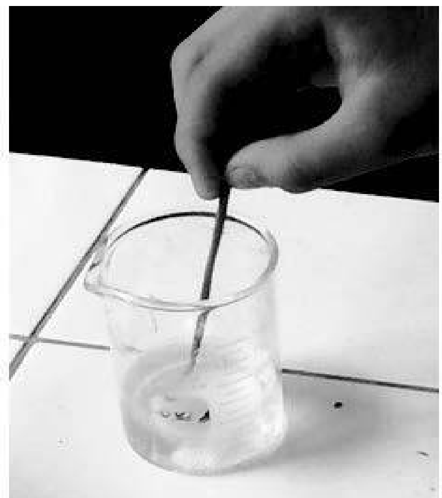


Figure 1

Table 3. Hydrogen Peroxide (Agua Oxigenada) Reaction

Material	Before Reaction	With addition of MnO_2
Agua oxigenada		

Procedure D. Vinegar and Baking Soda Reaction

This procedure should be done swiftly

1. Pour 20 mL of vinegar in a small beaker.
2. Get the temperature of vinegar.
3. Add a tablespoon of baking soda to the beaker.

Figure 2

Q8. What do you observe in the mixture?

1. Place a lighted match on top of the beaker near the bubbles. (Figure 2)
2. Observe what happens to the flame.

Q9. Describe what you observe in the flame.

Table 4. Vinegar and Baking Soda Reaction

	OBSERVATION	
Material	**Before Reaction**	**During Reaction**
vinegar		
baking soda		

Procedure E. Copper Sulfate-Sodium Hydroxide Reaction

1. Pour 5 mL of aqueous copper solution in one test tube.
2. Pour 5 mL of aqueous sodium hydroxide in another test tube.
3. Slowly combine the two solutions.
4. Observe what happens.

Q10. What did you observe at the bottom of the test tube?

5. Shake the mixture.
6. Observe what happens.

Q11. Compare the appearance before and after shaking

Table 5. Copper Sulfate-Sodium Hydroxide Reaction

APPEARANCE		
Materials	**Before Reaction**	**After Reaction (copper sulfate + sodium hydroxide)**
Copper sulfate solution		
hydroxide solution		

You have learned in your Grade 9 Chemistry that substances undergo chemical bonding so that atoms can become more stable. Chemical bonding results to breaking of bonds and formation of new bonds, thus new substances are formed. Formation of new substances means a chemical reaction has taken place.

KEY CONCEPTS:
When a physical change occurs there is no breaking and forming of bonds. There are certain things that will help us identify if a chemical reaction has taken place. We call these evidences of chemical reactions.

1. Production of light
2. Evolution of gas
3. Temperature change
4. Change in intrinsic properties (color, odor)
5. Formation of precipitate

Oxygen is vital to life. One interesting reaction which involves oxygen is the production of fire.

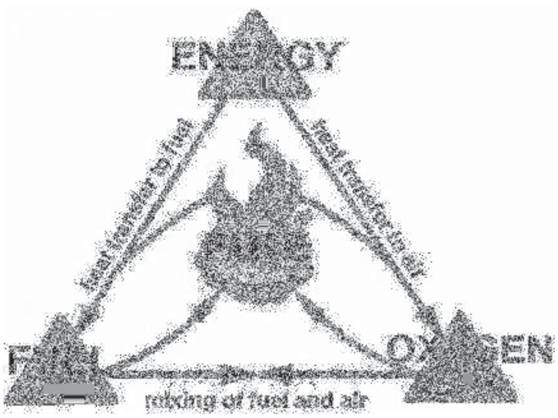
Fire has fascinated people for so long, that the ancient people even regarded it as one of the earliest elements. Fire was so important to them and they described it as an element that changes everything. The earliest theory about burning was the Phlogiston Theory. This theory by George Ernst Stahl in the 17th century stated that when a material burns, it releases a substance known as phlogiston, and this theory was accepted for a very long time.


Figure 3

Antoine Lavoisier through his careful observations from his experiments, debunked the phlogiston theory as he discovered that instead of releasing a substance (phlogiston) a material accurately burns as it reacts (uses) with oxygen. This is now known as the Theory of Oxidation, and this is accepted up to this day.

For burning to occur, 3 factors should be present in proper conditions and proportions.

1. Fuel
2. Oxygen
3. Heat



http://pslc.ws/fire/howwhy/triangle.htm
(accessed: (Mar.4, 2014)
Figure 4

In our country, we are reminded that March is a Fire Prevention month, as this month signals the start of summer, the season when countless fires break out all over the country, "An ounce of prevention is better than a pound of cure" is a motto we all need to remember.

Various materials acts as fuel to sustain fire, so various fire prevention and control measures are

Later as you progress in your lessons, you will get to learn more chemical reactions which may bring benefit or harm to life as well as to the environment.

In the next activity you will learn how chemical reactions can be presented in a shorter way. It is through this presentation that chemical reactions will later be analyzed for classification.

Activity 2

"What's in a Reaction?"

Objectives:

- Distinguish between reactants and products.
- Write a chemical equation.

A. Reactants and Products.

Reactants are substances that are used up to form new substances in a chemical reaction.

The following chemical reactions took place in Activity 1 procedure A to E.

1. Iron reacts with copper sulfate ($CuSO_4$) and forms iron (II) sulfate ($FeSO_4$) and copper.
2. Magnesium combines with oxygen gas (O_2) to produce magnesium oxide
3. Hydrogen peroxide (H_2O_2) in the presence of manganese dioxide (MnO_2) produces water and oxygen gas.
4. Acetic acid (CH_3COOH) and sodium bicarbonate ($NaHCO_3$) produce sodium acetate with the release of carbon dioxide (CO_2) gas and water.
5. Copper sulfate ($CuSO_4$) reacts with sodium hydroxide (NaOH) to produce insoluble copper (II) hydroxide $Cu(OH)_2$ and sodium sulfate (Na_2SO_4) solution.

Fill in the table below with the Reactants and Products from the chemical reactions above. Below each number, write the symbol or formula of the reactant and product.

Table 6. Reactants and Products

Reaction	Reactants	Products
1		
2		
3		
4		
5		

B. Symbols used in Chemical Equation

There are other symbols used in writing a chemical equations:

Table 7. Symbols and their Meanings

Symbol	Meaning
$+$	to show combination of reactants or products
$\longrightarrow$	To produce; to form; to yield
(s), (l), (g), (aq)	(s)-solid (l)-liquid (g)-gas (aq)-aqueous (substance is dissolved in water)
$\rightleftarrows$	Reversible reaction
$\xrightarrow{\text{Heat}}$ $\xrightarrow{\Delta}$	Indicates that heat is supplied to the reaction
$\xrightarrow[\text{Pt}]{}$	A formula written above or below the yield sign indicates its use as a catalyst or solvent

Using the symbols and formulas in Table 6 and the symbols in Table 7, write the chemical reaction using these symbols to complete chemical equation.

Table 8 Chemical Equation

Reaction	Chemical Equation
1	
2	
3	
4	
5	

KEY CONCEPTS:
A chemical equation is a chemist's shorthand for a chemical reaction. The equation distinguishes between the reactants, which are the starting materials and the products which are the resulting substance/s. It shows the symbols or formulas of the reactants and products, the phases (solid, liquid, gas) of these substances, and the ratio of the substances as they react.

In the next activity you will classify the chemical reactions you encountered in the laboratory activity "Everything has changed".

Activity 3

We Simply Click Together

Objectives:

- Classify reactions according to their types, based on how atoms are grouped or regrouped.
- Classify chemical reactions.

Materials:

- Activity Guide
- Students tabulated data from activity 2 “What’s in a Reaction?”

Procedure:

1. Bring out your filled up (answered) table from activity 2 ”What’s in a Reaction?”

Guide Questions:

Q12. In the second chemical reaction, how many reactants are used? How many product/s is/are formed?

Q13. In the third chemical reaction, how many reactants are used? How many product/s is/are formed?

Q14. In the first chemical reaction, what changes did copper and iron undergo during the reaction? What can you conclude about iron?

Q15. In the 4th chemical reactions, how many reactants and products are involved? What kind of substance are they?

Q16. In the fifth chemical reaction, both the reactants and products are compounds made up of positive and negative ions, what did you notice with the pairing of the positive and negative ions in the reactant and product side?

2. Refer to the guide card in classifying these six chemical reactions.

GUIDE CARD

A. COMBINATION (Synthesis) REACTION: A reaction when 2 or more reactants combine to form a single product.

The general formula for this reaction is :

$$A + B \longrightarrow AB$$

B. DECOMPOSITION REACTION: In this reaction, a single reactant breaks down into simpler ones. (2 or more products). This is the reverse of combination reaction.

The general formula for this reaction is:

$$AB \longrightarrow A + B$$

C. SINGLE DISPLACEMENT (Replacement) REACTION: This is when one element replaces another element from a compound. The more active element takes the place of the less active element in a compound.

The general formula for this reaction is:

$$A + BC \longrightarrow AC + B$$

D. DOUBLE DISPLACEMENT REACTION (Metathesis): This is when the positive ions (cations) and negative ions (anions) of different compounds switch places, forming two entirely different compounds.

The general formula for this reaction is:

$$AB + CD \longrightarrow AD + CB$$

E. COMBUSTION (Burning) REACTION: This is when oxygen combines with a hydrocarbon (compound containing hydrogen and carbon) to form a water and carbon dioxide. Example of which is the burning of butane gas

$$C_4H_{10} + O_2 \longrightarrow CO_2 + H_2O$$

F. ACID-BASE REACTION: This is a speacial kind of double displacement reaction that takes place when an acid and base react with each other. The H+ of the acid reacts with the OH- of the base forming water. The other product is salt. Example of which is:

$$HCl + NaOH \longrightarrow NaCl = H_2O$$

Table 9. Types of Chemical Reactions

Reaction	Chemical Equation	Type of Chemical Reaction
1		
2		
3		
4		
5		

KEY CONCEPTS:

Chemical reactions can be classified according to the following types:

A. COMBINATION REACTION: Reactants combine to form a single product. The general formula for this reaction is:

A + B ------→ AB

B. DECOMPOSITION REACTION: In this reaction, a single reactant breaks down into simpler ones. (2 or more products). This is the reverse of combination reaction. The general formula for this reaction is

: AB ------→ A + B

C. SINGLE DISPLACEMENT (Replacement) REACTION. This is when one element replaces another element from a compound. The more active element takes the place of the less active element in a compound. The general formula for this reaction is:

A + BC ------→ AC + B

D. DOUBLE DISPLACEMENT REACTION (Metathesis). This is when the positive ions (cations) and negative ions (anions) of different compounds switch places, froming two entirely different compounds. The general formula for this reaction is:

AB + CD → AD + CB

E. COMBUSTION (Burning) REACTION This when oxygen combines with a hydrocarbon to form water and carbon dioxide.

F. ACID-BASE REACTION: This is a special kind of double displacement that takes place when an acid and base react with each other.

HCl + NaOH ----→ NaCl + H2O

ENRICHMENT:

Classify the following unbalanced chemical equations according to the six types of chemical reactions.

A. Combination
B. Decomposition
C. Single displacement
D. Double displacement
E. Combustion
F. Acid-base

1. $NaOH + KNO_3 \rightarrow NaNO_3 + KOH$
2. $CH_4 + O_2 \rightarrow CO_2 + 2\,H_2O$
3. $Fe + NaBr \rightarrow FeBr_3 + Na$
4. $CaSO_4 + Mg(OH)_2 \rightarrow Ca(OH)_2 + MgSO_4$
5. $NH_4OH + HBr \rightarrow H_2O + NH_4Br$
6. $P_4 + O_2 \rightarrow P_2O_5$
7. $NaNO_3 \rightarrow NaNO_2 + O_2$
8. $C_{18}H_{18} + O_2 \rightarrow CO_2 + H_2O$
9. $H_2SO_4 + NaOH \rightarrow NaSO_4 + H_2O$
10. $NiSO_4 + Li_3PO_4 \rightarrow Ni_3(PO_4)_2 + Li_2SO_4$

In the next activity, you will see how mass is conserved during a chemical reaction and how this is explained by the Law of Conservation of Mass.

Activity 4

How much can you take?

Objective:

- Perform an activity that illustrates Law of Conservation of Mass.

Part 1. Laboratory Activity on Law of Conservation of Mass

Materials:

- Steel wool
- 10% $CuSO_4$ solution
- Test tube
- Rubber/cork stopper
- Test tube holder
- Beaker
- Alcohol burner
- Wire gauze
- Tripod
- Matches

Procedure:

1. Place a dry and clean test tube and a rubber/ cork stopper in a dry and clean 100 mL-beaker.
2. Get the total mass of the dry and clean test tube and the stopper, and the 100 mL-beaker. Record it in Table 10.

3. Place a small portion of steel wool in the test tube.
4. Add 10 mL $CuSO_4$ solution.
5. Cover the mouth of the test tube with the rubber/ cork stopper .
6. Get the mass of the set-up using the same 100mL-beaker. Record the mass in Table 10.
7. Heat the lower part of the test tube gently for 2 minutes while moving it to and fro. Make sure that the rubber/ cork stopper covers the mouth of the test tube and the test tube is held with a test tube holder in a slanted position.

Q17. Describe the appearance of the steel wool.

Q18. What is the evidence that a chemical change happened?

8. Allow the test tube to cool completely in the 100-mL beaker.
9. Get the mass of the set-up again. Record your observation in Table 10.

Table 10. Law of Conservation of Mass

BEFORE HEATING	**Mass (g)**
(a) Mass of the test tube, stopper, and beaker	
(b) Mass of the test tube, stopper, and beaker and Mass of the Steel wool + $CuSO_4$ solution	
(c) Mass of the Steel wool + $CuSO_4$ solution [(b)+(a)]	Total Mass of Reactants:
AFTER HEATING	
(d) Mass of the test tube, stopper, and beaker and Mass of the Steel wool + $CuSO_4$	
(e) Mass of the Steel wool + $CuSO_4$ solution [(d)-(a)]	

Q19. Why is it important for the test tube to be sealed?

Q20. How will you compare the total mass before and after the reaction ?

Part 2. Paper Clip Reaction Model

Materials:

- 1 box of different colored paper clips
- Periodic table

Procedure:

1. Sort out your paper clips according to color. Designate a color for each element.

Element	Color of paper clip
Hydrogen (H)	White
Nitrogen (N)	Blue
Oxygen (O)	Red

2. By connecting paper clips together (follow the color coding in number (1), make model representations for these molecules :

   a. $\mathbf{O_2}$, $\mathbf{H_2}$, $\mathbf{H_2O}$ Prepare at least 3 sets of each molecule as shown in the figure below.

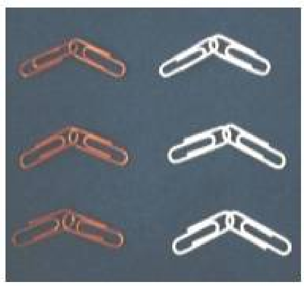


Figure 5.1

Figure 5.2

   b. $\mathbf{N_2}$, $\mathbf{H_2}$, $\mathbf{NH_3}$ Prepare at least 4 sets of each molecule

Figure 6.1

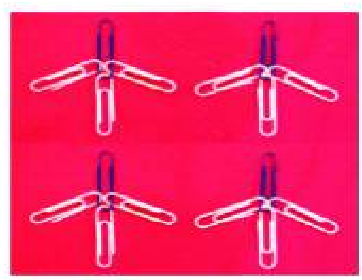


Figure 6.2

3. You will be working on balancing 2 chemical equations.
   a. $\mathbf{H_2 + O_2 \rightarrow H_2O}$
   b. $\mathbf{N_2 + H_2 \rightarrow NH_3}$

4. Starting with the first equation:
   a. Break up one set of $\mathbf{O_2}$ **since $\mathbf{H_2O}$ has only 1 Oxygen.**
   b. Connect this single O atom to the one set of H_2 you have prepared to form 1 set of H_2O
   c. Get another set of H_2 and connect to the single O atom left to form a new set of H_2O.

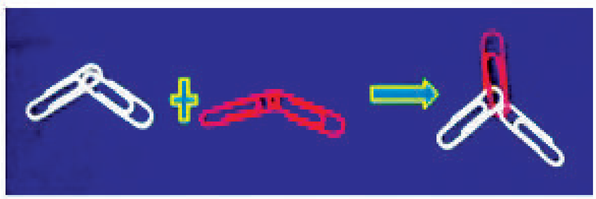
Guide Questions:

Q21. How many set/s of H_2 have you used? ______

Q22. How many set/s of O_2 have you used? ______

Q23. How many set/s of H_2O have you created? ______
These number of set/s represent **coefficient** which is the whole number placed before the formula of the reactants and products.

Q24. Write the corresponding coefficients in the chemical equation.



$$\_\_\_\_\_\ \mathbf{H_2} \ + \ \_\_\_\_\_\ \mathbf{O_2} \ > \ \_\_\_\_\_\ \mathbf{H_2O}$$

Figure 7

NOTE: If there is only one set, we do not write 1 anymore.

5. Do the same with the second equation

$$\_\_\_\_\ \mathbf{N_2} \ + \ \_\_\_\_\ \mathbf{H_2} \ \rightarrow \ \_\_\_\_\ \mathbf{NH_3}$$

NOTE: You can use more than 2 sets.

Guide Questions:

Q25. How many set/s of $\mathbf{N_2}$ have you used? ______

Q26. How many set/s of $\mathbf{H_2}$ have you used? ______

Q27. How many set/s of $\mathbf{NH_3}$ have you created? ______

Q28. Write the corresponding coefficients in the chemical equation.

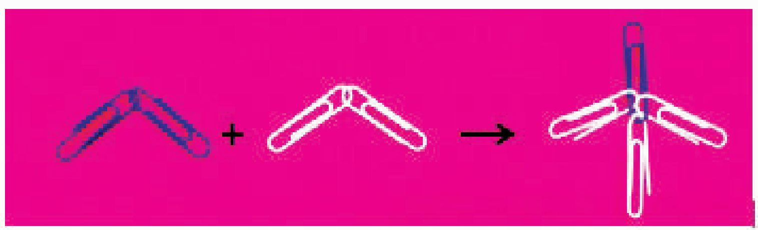
$$\_\_\_\_\ \mathbf{N_2} \ + \ \_\_\_\_\ \mathbf{H_2} \ \rightarrow \ \_\_\_\_\ \mathbf{NH_3}$$

NOTE: If there is only one set , we do not write 1 anymore.

6. Get the molar mass of N_2, H_2, and NH_3, multiply their masses by their coefficient, then get the total mass of the reactants and compare to the total mass of the products. The first equation is done for you.
   molar mass (g/mol) : H=1 O=16 N=14

$$
\begin{array}{ccccc}
\mathbf{2\,H_2} & \mathbf{+} & \mathbf{O_2} & \rightarrow & \mathbf{2\,H_2O} \\
2(2\ \text{x}1\text{g/mol}) & + & (2\ \text{x}\ 16\text{g/mol}) & \rightarrow & 2\ [\ (2\text{x}\ 1\text{g/mol}) + 16\text{g/mol}\ ] \\
4\ \text{g/mol} & + & 32\ \text{g/mol} & \rightarrow & 2\ (\ 18\ \text{g/mol}) \\
 & & \mathbf{36g} & \rightarrow & \mathbf{36g}
\end{array}
$$

Q29. Do the same with the second equation



_____N_2 + _____H_2 > _____NH_3

Figure 8

Q30. How will you compare the total mass of the reactants and the total mass of the products?

This now follows the Law of Conservation of Mass.

KEY CONCEPTS:
Law of Conservation of Mass states that mass is conserved in a chemical reaction. The total mass of the reactants is equal to the total mass of the products. No new atoms are created or destroyed, there was only grouping or regrouping (rearrangement) of atoms.

The next activity reinforces your knowledge of Law of Conservation of Mass by balancing the chemical equations, involving the chemical reactions in the previous activity you performed.

Activity 5

Balancing Act

Objectives:

- Recognize that the number of atoms of each element is conserved in a chemical reaction as atoms in the reactants only rearrange themselves to form the products
- Apply the concept of Law of Conservation of Mass in balancing chemical equations

Material:

Table 11. Types of Chemical Reactions

Reaction	Chemical Equation	Type of Chemical Reaction
1		
2		
3		
4		
5		

Procedure:

1. Analyze the informations that can be gathered in the chemical equation :

$$2\,H_2 + O_2 \rightarrow 2\,H_2O$$

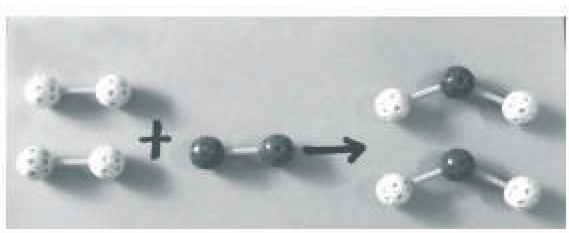


Figure 9

2 molecules of H_2 + 1 molecule of O_2 → 2 molecules of H_2O
2 moles of H_2 + 1 mole of O_2 → 2 moles of H_2O
4 atoms of H + 2 atoms of O → 4 atoms of H and 2 atoms of O

Note that the **coefficient** (number) placed before the formulas indicate the number of molecules or moles.

Determining the correct coefficients balances the number of atoms in the reactant and in the product side, allowing it to follow the Law of Conservation of Mass.

2. Bring out your data on Table 9 Types of Chemical Reactions, balance the chemical equations guided by the steps in balancing equations below this table.

Table 11. Balanced Chemical Equations

Reaction	Chemical Equation	Type of Chemical Reaction
1		
2		
3		
4		
5		

Steps in Balancing Equations:

Write the unbalanced chemical equation, make sure you have followed correctly the rules in writing formulas of compounds.

- Take note of the elements present in the reactant and product side.
- Count the number of atom/s of each element present in the reactant and product side.
- Apply the Law of Conservation of Mass to get the same number of atoms of every element on each side of the equation.Balance chemical equations by placing the appropriate coefficients before the symbol or formula. Do not change the subscripts of the formula in an attempt to balance the equation as it will change the identity of the components.

KEY CONCEPTS:

- For a chemical equation to conform to the Law of Conservation of Mass, it has to be balanced.
- Chemical equations are balanced by placing the appropriate coefficients before the symbols or formulas of reactants and products.
- Certain steps are observed in balancing reactions.

ENRICHMENT:

Balance the following chemical equations, making sure to apply the principle of the Law of Conservation of Mass.

1. $Zn + HCl \rightarrow ZnCl_2 + H_2$
2. $CH_4 + O_2 \rightarrow CO_2 + H_2O$
3. $Fe + NaBr \rightarrow FeBr_3 + Na$
4. $SiCl_4 + H_2O \rightarrow SiO_2 + HCl$
5. $N_2 + O_2 + H_2O \rightarrow HNO_3$
6. $P_4 + O_2 \rightarrow P_2O_5$
7. $NaNO_3 \rightarrow NaNO_2 + O_2$
8. $C_3H_8 + O_2 \rightarrow CO_2 + H_2O$
9. $Fe + H_2O \rightarrow H_2 + Fe_3O_4$
10. $Al + O_2 \rightarrow Al_2O_3$

A burning vehicle and a puppy are undergoing a similar kind of chemical reaction. What reaction could this be?

In the next activity you will learn why chemical reactions occur and why they occur at different rates.

Activity 6

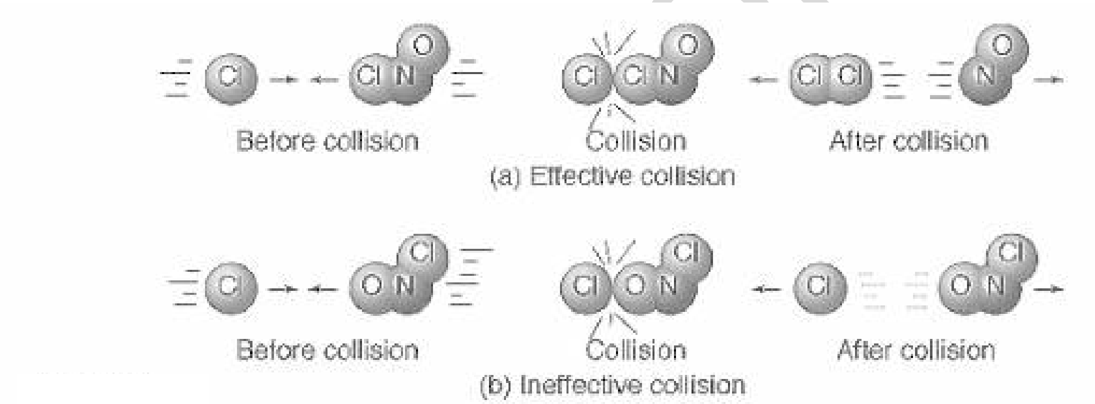
Race to the Finish Line

Objectives:

- explain how the factors affecting rates of chemical reactions are applied in food preservation, control of fire, pollution, corrosion and materials production
- recognize the importance of controlling rates of reactions in technology

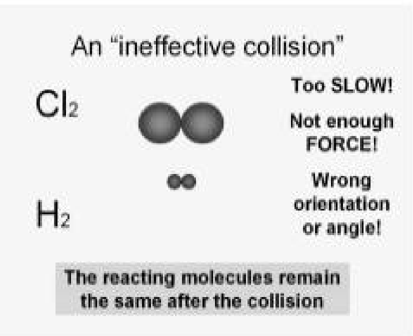
Part 1. Collision Theory

Task: Analysis of molecular representation of collision theory.



Source: http://wps.prenhall.com/wps/media/objects/3082/3156859/blb1404/bl14fg16.jpg (accessed: Oct.29, 2014)

Figure 10



Source: http://i.ytimg.com/vi/OkGzaSOkyf4/maxresdefault.jpg (accessed: Oct.29, 2014)

Figure 11

The illustrations above show the effective and ineffective collision of molecules to effect a chemical reaction.

Guide Questions:

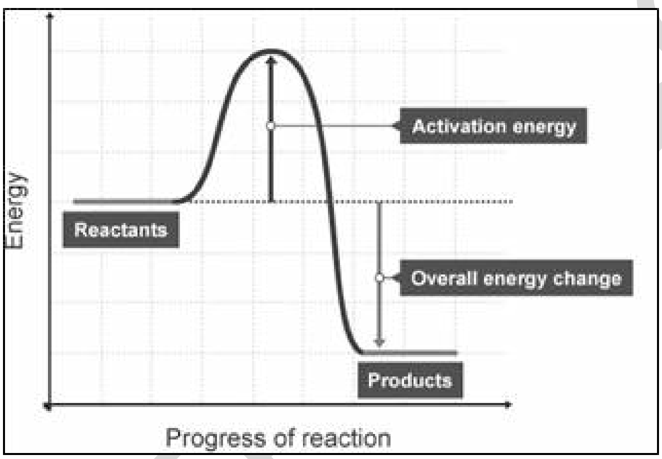
Q31. What causes a chemical reaction?

Q32. What must happen for a chemical reaction to take place?

Q33. Describe fruitful / effective collision resulting to formation of products.

In 1888 Svante Arrhenius suggested that particles must possess a certain minimum amount of kinetic energy in order to react. The energy diagram is shown below.

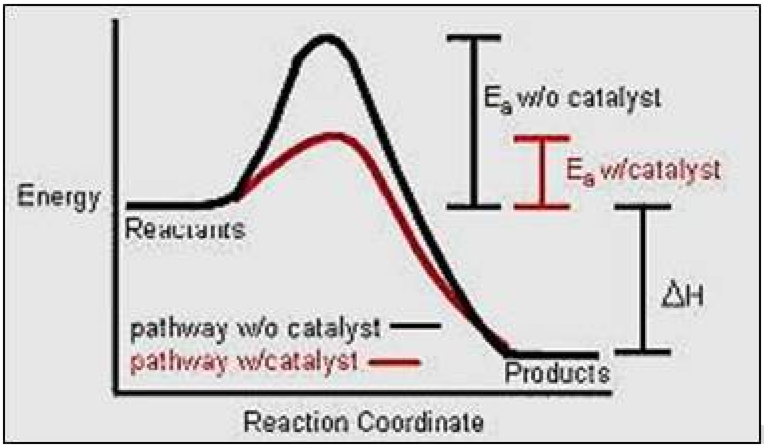
Energy diagrams are used to analyze the changes in energy that occur during a chemical reaction. The energy of the reactants must be raised up over an energy barrier.



Activation energy is the energy required to initiate a reaction and force the reactants to form an activated complex.The activated complex is located at the peak of the energy diagram for a reaction.

Source: http://www.bing.com/images/search?q=Activation+enegy&go=&qs=n&form=QBIR&pq=activation+energy&sc=8-17&sp=- (1&sk=#view=detail&id=C4330FFCC22298D71798C4462372111054F635D6&selectedIndex=96 (Accessed: July 4, 2014)

Figure 11.1



Source: https://www.chem.tamu.edu/class/majors/tutorialnotefiles/factors.htm (accessed: July 4, 2014)

Figure 11.2

Q34. What is the effect of a catalyst on the activation energy?

COLLISION THEORY:

Collision theory explains how collision between reactant molecules may or may not result in a successful chemical reaction.

Based this theory, not all collisions between the molecules result in the formation of products. Effective collisions between molecules, which result in the formation of products, only occur when the following two conditions are met:

(a) the colliding molecules should possess a minimum kinetic energy, known as activation energy, to start a chemical reaction.

(b) the reactant molecules should be in correct orientation when they collide.

Activation energy is needed to break the bond between reactant molecules to form new bonds leading to formation of the products.

KEY CONCEPTS:
COLLISION THEORY: Reactions can only happen when the reactant particles collide, but most collisions are NOT successful in forming product molecules despite the high rate of collisions. Reactants should have sufficient energy, and their molecules should be in proper orientation for a successful collision to happen.
The minimum kinetic energy required for reaction is known as the activation energy.

PART 2: Factors Affecting Reaction Rates
In this experiment, students will study the effect that temperature, reactant concentration, particle size, catalysts and surface area have on chemical reaction rates.

Equipments:

- 7 clear plastic cups
- mortar and pestle
- 2 medium sized test tubes
- 2 test tube holders

Reagents:

- 20 volume hydrogen peroxide (Agua oxigenada)
- Manganese dioxide
- water
- 4 seltzer tablets or denture cleaner in tablet form
- 3 5cm x 5cm colored crepe paper/ Japanese paper
- 25% household bleach solution
- 50% household bleach solution
- 75% household bleach solution

A. Effect of Particle Size or Surface Area on Reaction Rate

Procedure:

1. Get 2 clear plastic cups, half fill each plastic cups with water.

2. Obtain two denture cleaner tablets. Powderize one tablet using mortar and pestle.
3. Simultaneously drop the whole tablet and powderized tablet in the 2 separate plastic cups.
4. Observe the reactions for several minutes and record the time it takes for each tablet to stop fizzing .

Table 12. Effect of Particle Size or Surface Area on Reaction Rate

Effect of Particle Size of Surface Area on Reaction Rate	
Reaction Condition	**Reaction Rate** **Time (sec)**
denture cleaner (whole) in water	
denture cleaner (powderized) in water	

Guide Questions:

Q35. a. Which tablet fizzed for a longer period of time?
b. How might you explain any difference ?

Q36. a. Describe in your own words the effect of particle size or surface area on the rate of a reaction.

B. Effect of Temperature on Reaction Rate

Procedure

5. Fill one glass with cold water and another glass with hot water.
6. Drop a denture cleaner tablet into each glass.
7. Observe the reactions that occur. Record the time it takes for each tablet to stop fizzing .

Q37. Is there any noticeable difference between the two reactions?
Q38. What is the effect of temperature on reaction rate?

Table 13. Effect of Temperature on Reaction Rate

Effect of Particle Size of Surface Area on Reaction Rate	
Reaction Condition	**Reaction Rate Time (sec)**
denture tablet in cold water	
denture tablet in hot water	

C. Effect of a Catalyst on Reaction Rate

Figure 12

8. Place 10mL of hydrogen peroxide (H_2O_2) in 2 separate test tubes. Place one test tube in a hot water bath.
   Note the rate bubbles form.
9. Add a pinch of manganese dioxide in the second test tube.
   Note the rate bubbles form.

Q39. How will you compare the rate at which bubbles were produced?

Q40. Study the chemical equation below.

Chemical Equation: $H_2O_{2\ (l)} \xrightarrow[MnO_2]{} H_2O_{(l)} + O_{2\ (g)}$

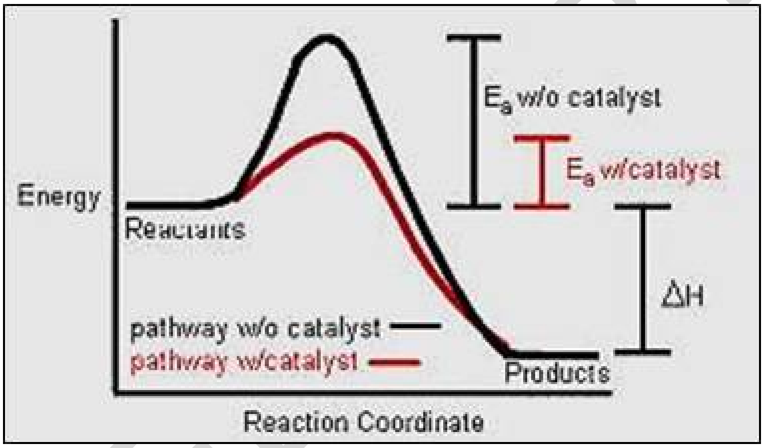
Notice the reactants and resulting products.

Q41. Where is the MnO_2 written in the equation?

Q42. Do you think the MnO_2 reacted with H_2O_2 ?

Q43. MnO_2 only acted as a catalyst. What role do you think a catalyst play in a chemical reaction?

Going back to the diagram below, recall the effect of catalyst on activation energy .



D. Effect of Concentration on Reaction Rate

Caution: Wear a mask while performing this experiment.

Procedure:

10. Prepare in separate plastic cups, different concentrations of household bleach solution
    100% (no water added)
    50% (half part bleach solution- half part water)
    25% (1/4 part bleach solution – ¾ part water) .

11. Prepare 3 pieces of 5cm x 5cm sized brightly colored crepe paper or Japanese paper.

12. Drop the pieces of crepe paper into the 3 plastic cups simultaneously.

13. Compare the rate of discolorization of the papers in the 3 beakers. Record your observation in the table below.

Table 14. Effect of Concentration on Reaction Rate

Concentration	Reaction Rate
25% solution	
50% solution	
100% solution	

Q44. Did you get the same rate of reaction?

Q45. Describe in your own words the effect of concentration on the rates of reaction.

Q46. How will you explain using the Collision theory the factors affecting reaction :

a. Surface area of reactants
b. Temperature
c. Catalyst
d. Concentration

KEY CONCEPTS:

The rate of chemical reaction is affected by the following factors: temperature, surface area of reactants, presence of catalyst, concentration of reactants.

Every factor that affects reaction rate can be understood relative to collision theory.

ENRICHMENT:

Write TRUE on the space provided if the statement is correct.

Rewrite the statement, if the statement is false.

1. Catalysts speed up chemical reactions but are not changed by them.
2. Heat, light, or change in odor can indicate a physical change.
3. Activation energy is the minimum energy required for reactions to start.
4. Low temperature speeds up reaction rates.
5. A low concentration of chemical slows reaction rate.

The following activity, will deepen your understanding of the benefits and harm posed by some chemical reactions, and will guide you in exploring why rate of some chemical reactions need to be controlled.

Activity 7

Making Connections

Objectives:

- Explain how factors affecting the rate of chemical reactions are applied in food preparation, control of fire, corrosion prevention, etc.
- Analyze effect of chemical reactions on life and the environment through visual presentation.

PART 1.

1. Analysis of set of pictures linking to acid rain :

What effect does acid rain has on limestone/ marble statues?

http://www.petersommer.com/blog/category/news/exhibitions/

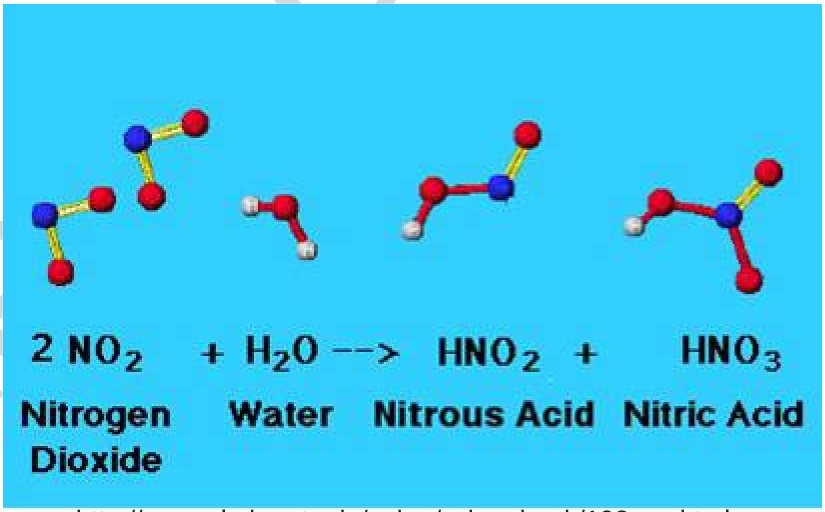
Figure 13. Effect of Acid Rain on Marble

What effect does acid rain has on plant growth?

http://www.connecticutvalleybiological.com/acid-rain-and-the-environment-acidity-and-plant-growth-p-15860.html

Figure 14. Effect of Acid Ran oon Plant Growth

Nitric oxide NO_2, a product of combustion of gasoline in automobiles is one of the culprits in the formation of acid rain. Referring to Fig. 15, analyze how NO_2 is converted to nitric acid HNO_3



http://www.elmhurst.edu/~chm/vchembook/193nox.html

Figure 15. Reaction of Nitrogen Dioxide with Water

From Figure 16, identify other problems posed by acid rain.

http://envis.tropmet.res.in/menu/ENVIS_Acid_Rain/images/acidImage/Acid_Rain_Arriving.png

Figure 16

2. Discussion on acid rain, a chemical reaction that has environmental issues.

An example of a chemical reaction that has an environmental concern is the acid rain.

Acid rain has been the leading significant cause of destruction in our environment. In infrastructure, it is the cause of corrosion of metals in alloys like steel in buildings, bridges, and transport vehicles. This is due to the displacement reaction of active metals with hydrogen in acids.

Materials with historical and cultural values such as monuments and statues are also destroyed by acid rain. They are mostly made up of limestone and marble which like metals form a chemical reaction with acids, lead to their dissolution.

Marine life is also affected by acid rain. It causes the pH of bodies of water to decrease; this change in pH will increase marine life mortality, retard fish growth, decrease egg production and embryo survival.

Acid rain also tends to dissolve vital minerals in the soil. Crops grown in these depleted soils give poor yields, if they grow at all.

In areas of high automobile traffic, such as in large cities, the amount of nitrogen oxides emitted into the atmosphere can be quite significant. In urban areas, the main source of acid rain is from automobiles. Other sources are thermal power plants and coal mining industries. Gas emissions like CO2, CO, SO2, NO2, and NO from these sources react with water vapor in the air producing acids. Rain contaminated with these acids are what we know now as acid rain.

Removing the offending oxides from exhaust and using alternate energy sources are much preferred courses of action at the present time. One of the most important means of reducing sulfur emissions is the swith to low sulfur fuels. Another is the scrubbing of stack gases before they are released to the atmosphere. In this process, the stack gases percolate through a solution that absorbs the oxides of sulfur. The solution is renewed frequently, and waste sulfur can be recovered from the spent solution.

Analyzing the issue:

Q47. What natural processes can contribute to acid rain?

Q48. How is acid rain produced?

Q49. What adverse effect can acid rain pose on living organisms and its environment?

Q50. Who should be responsible for cleaning up the pollution problem?

Q51. What measures are taken to address the problem?

PART 2 : Visual presentation (any form of media) of the effects of chemical reactions on life and the environment

Group Activity

1. Using any form of media, prepare a visual presentation of a chemical reaction involved in:
    a. Food processing and preservation
    b. Fire control
    c. Corrosion Control
    d. Photochemical Smog
    e. Haber Process
    f. Catalytic Converter
    g. Car air bag
    h. formation of ozone layer in the stratosphere
    i. formation of acid rain

2. Research on how a specific chemical reaction poses useful or harmful effects to life and the environment.

3. Present to class your visual presentation

- During your planning session, be reminded to follow the **GRASP Task Design Prompts** to assist you in the organization of your activity.

Goal

Your task is to create a visual presentation of benefits/ harm posed by a particular chemical reaction using any form of media.

Role

You have been asked to gather/ collect researches on chemical reaction assigned to your group.

Your job is to understand fully the concepts and issues involved.

Audience

The target audience is the whole class and a local public official (e.g., barangay chairman) or a member of your community who may be involved in your assigned topic. You need to encourage/ convince your audience to draw pledges/ policies that will help mitigate the problem/ promote the benefits in your topic.

Situation

The challenge has to do with preparation of the visual presentation: choosing and documenting appropriate resources, summarizing and making the research coherent.

Product, Performance and Purpose

You will create a visual presentation supported by research in order to better understand and appreciate the principles involved in chemical reactions.

Standards and Criteria for Success

Your performance needs to meet the following criteria:

- Creative (visual presentation is clear/visually appealing)
- Meaningful (giving importance to the understanding of the benefits and harm posed)
- Illustrative (discussing thoroughly how these reactions may cause harm or how we can benefit from them)

Though this is a group task, you will individually assess your performance using the Critical Thinking Rubric below.

Critical Thinking Rubric:

	4	3	2	1
Identifying the important information	I determine what concepts and relationships are important in a complex system of abstract and concrete information.	I can usually tell what concepts and relationships are important in a system.	Sometimes, I have trouble telling the difference between important and unimportant concepts and relationships in a system.	I often get important and unimportant information mixed up.
Making Inferences	I use what I know about the subject along with my personal experiences and knowledge to make reasonable inferences. I use my inferences to draw conclusions about information.	I analyze new information and make reasonable inferences.	With help, I can make inferences, but sometimes my inferences are not based on good reasons.	I usually cannot make inferences about what I am learning.

	4	3	2	1
Evaluating Sources	I use several strategies for evaluating the reliability of a variety of different kinds of sources.	I use some strategies for evaluating sources.	Sometimes, I am fooled by information that is not reliable.	I often cannot tell the difference between reliable and false information.
Learning Independently	I do whatever I need to do to learn more about ideas and concepts that are new to me.	I make an effort to learn more about ideas and concepts that are new to me.	If someone reminds me, I learn more about ideas and concepts that are new to me.	I am usually happy with what I already know about information, and I do not bother to find out more.
Communicating	I can clearly and thoroughly explain my opinions by giving good reasons for them, orally and in writing.	I can explain my opinions by giving good reasons for them, orally and in writing.	With prompting and guidance, I can explain my opinions orally and in writing.	I cannot explain my opinions so that they make sense.

IV. Summary/Synthesis/Feedback

- **<u>Reactants</u>** are the substances that enter into a chemical reaction, and **<u>products</u>** are the resulting substances. Substances that undergo a chemical reaction experience a change in their physical and chemical properties.
- When a physical change occurs there is no breaking and forming of bonds. There are certain things that will help us identify if a chemical reaction has taken place. We call these <u>evidences of chemical reactions</u>. These are: production of light, evolution of gas, temperature change, color change, and formation of precipitate.
- A **chemical equation** is a chemist's shorthand for a chemical reaction. The equation distinguishes between the **reactants**, which are the starting materials and the **products** which are the resulting substance/s. It shows the symbols or formulas of the reactants and products, the phases (solid, liquid, gas) of these substances, the ratio of the substances as they react.
- Chemical reactions are classified in to the following types:

  combination: $A + B \rightarrow AB$

  decomposition: $AB \rightarrow A + B$

  single displacement: $A + BC \rightarrow AC + B$

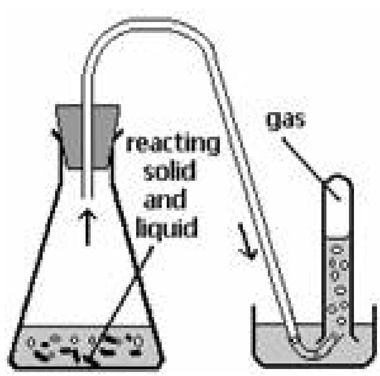
  double displacement: $AB + CD \rightarrow AD + CB$

  combustion (reaction with oxygen producing carbon dioxide and water),

  acid-base: reaction between acid and base
- **COLLISION THEORY**: Reactions can only happen when the reactant particles collide. Reactants should have sufficient energy, and their molecules should be in proper orientation for a successful collision to happen.
- Activation Energy, Ea, is the minimum amount of energy needed for a reaction to occur.
- The rate of chemical reaction is affected by the following factors: temperature, surface area of reactants, presence of catalyst, concentration of reactants.
- Every factor that affects reaction rate can be understood relative to Collision theory.

V. Summative Assessment

I. Multiple Choice: Choose the correct answer.

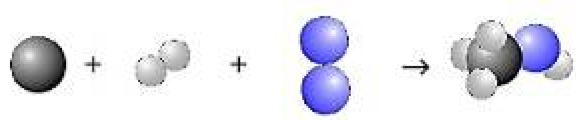


1. Analyze the diagram on the left, what evidence shows that the reaction's product is a gas?
   a. bubbles are forming and collected
   b. the gas is not soluble in water
   c. acids always produce gases when they react with a solid
   d. there is no filter funnel and paper to remove unreacted solid.

2-3 Refer to the illustration below:

The following depicts the formation of methanol (CH_3OH).

carbon + hydrogen gas + oxygen gas → methanol



2. What would be the skeleton equation for this reaction?
   a. $C + Cl_2 + O_2 \rightarrow CH_3ClH$
   b. $C + H_2 + O_2 \rightarrow CH_3OH$
   c. $C_2 + H_2 + O_2 \rightarrow CH_3OH$
   d. $C + H + O \rightarrow CH_3OH$

3. If the formula for methanol is CH_3OH, what would be the balanced chemical equation for this reaction?
   a. $C_3 + 2H_2 + O_2 \rightarrow 2CH_3OH$
   b. $2C + 4H_2 + O_2 \rightarrow 2CH_3OH$
   c. $2C + 2H_2 + O_2 \rightarrow 2CH_3OH$
   d. $C + H + O \rightarrow CH_3OH$

4. Which of the following is the correct balanced reaction?
   a. $2\ C_3H_8 + 10O_2 \rightarrow 6CO_2 + 8H_2O$
   b. $C_3H_8 + O_2 \rightarrow CO_2 + H_2O$
   c. $C_3H_8 + O_2 \rightarrow 3CO_2 + 2H_2O$
   d. $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

5. Quicklime (CaO) is used as a drying agent. When water is added to this, slaked lime $Ca(OH)_2$ is formed. What type of reaction is this?
   a. combination
   b. single displacement
   c. decomposition
   d. double displacement

6. Fresh fish and meat that are not stored in a refrigerator show signs of spoilage in less than a day. What has caused this spoilage?
   a. temperature changes
   b. presence of microorganisms
   c. oxygen in air
   d. all of the above

7. The rate of reaction increases as the temperature increases. Which of the following statements provides the best explanation for this?
   a. At lower temperatures the particles do not collide with each other.
   b. At higher temperatures the particles have more energy, move faster, and collide more often.
   c. Higher temperature has higher activation energy.
   d. Increasing the temperature increases the number of particles, so they collide more often.

8. Which of the following statements about collisions is correct?
   a. Reaction will occur even without collision of molecules.
   b. All colliding particles have the same amount of energy.
   c. Only fast-moving particles collide with each other.
   d. Reactions can happen if the colliding particles have enough energy.

9. Reactions eventually stop. What is generally the reason for this?
   a. The catalyst has been used up.
   b. The particles have run out of energy.
   c. One or more of the reactants has been used up.
   d. Wrong catalyst was used.

10. In a reaction with hydrochloric acid, why does powdered magnesium reacts faster than the same mass of magnesium ribbon?
    a. The powdered magnesium contains more atoms than the magnesium ribbon.
    b. The powdered magnesium is hotter than the magnesium ribbon.
    c. The powdered magnesium has a bigger surface area than the magnesium ribbon.
    d. The powdered magnesium has a smaller surface area than the magnesium ribbon.

11. Marble reacts with hydrochloric acid to produce calcium chloride, water and carbon dioxide. In which of these mixtures is the rate of reaction likely to be the greatest?
    a. 1 g of marble chips in 100 cm^3 of hydrochloric acid at 20°C.
    b. 1 g of powdered marble in 100 cm^3 of hydrochloric acid at 30°C.
    c. 1 g of powdered marble in 100 cm^3 of hydrochloric acid at 20°C.
    d. 1 g of marble chips in 100cm^3 of hydrochloric acid at 30°C.

12. Manganese dioxide is a black powder that catalyzes the breakdown of hydrogen peroxide to water and oxygen. Which of the following statements is correct?
    a. The mass of manganese dioxide will stay the same during the reaction.
    b. The catalyzed reaction will produce more oxygen than the uncatalyzed reaction.
    c. The particles in the catalyzed reaction will have more energy than in the uncatalyzed reaction.
    d. Manganese dioxide will cause production of more water.

13-15 Explain briefly.

13-15 Based on your knowledge of factors affecting the rate of reaction, why is there a danger of explosion in places like coal mines where there are large quantities of powdered, combustible materials?

Glossary of Terms

Acid-base reaction	Reaction between an acid and a base producing salt and water.
Activated complex	The specie temporarily formed by the reactant molecules as a result of collision before they form the product.
Activation energy	The minimum amount of energy required to start a chemical reaction.
Catalyst	A substance that hastens a chemical reaction without itself being consumed.
Chemical equation	An equation that uses chemical symbols and formulas to represent a chemical reaction
Chemical reaction	A process in which a substance is changed into one or more new substance/s.
Coefficient	The number placed before the formulas, used to balance a chemical equation.
Collision Theory	Reactions can only happen when the reactant particles collide.
Combination reaction	Two or more reactants form a single product.
Combustion reaction	Reaction with oxygen producing water and carbon dioxide.
Decomposition reaction	A single reactant breaks down into 2 or more products.
Double displacement reaction	This is when the positive ions (cations) and negative ions (anions) of different compounds switch places, forming two entirely new compounds.
Inhibitor	Substance that slows down or retards a chemical reaction.
Precipitate	An insoluble solid that separates from the solution.
Product	The resulting substance after a chemical reaction.
Reactant	The substance entering a chemical reaction.
Single displacement reaction	A more active element replaces another element from a compound.
Smog	Coined from the words smoke and fog, an environmental pollutant.

References and Links

Printed Materials:

Chang (2006)Chemistry 11th Edition McGraw-Hill IncNew York
Le May, Beall, Robblee , Brower (2000) *Chemistry Connections to Our Changing World* Teachers edition Prentice Hall Upper Saddle River, NJ
Padolina, Antero, Alumaga (2010) Conceptual and Functional Chemistry Modular Approach Vibal Publishing House, Quezon City Phil.,
Silverberg (2006) *Chemistry* 4th Edition Mc Graw-Hill Inc New York
Wilbraham , Staley, Matta Waterman (2002) Chemistry Prentice Hall Inc, New Jersey
Zumdahl (2000) Basic Chemistry 4th edition Houghton Mifflin Co, New York
Dep Ed Project EASE Module 17 Lesson 1

Electronic Sources:

http://www.elmhurst.edu/~chm/vchembook/193nox.html
http://chemistry.mtu.edu/~pcharles/SCIHISTORY/PhlogistonTheory.html
How to prevent fire http://www.ulm.edu/police/fire-extinguishers
http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa_pre_2011/chemreac/energychangesrev3.shtml
http://www.bbc.co.uk/schools/gcsebitesize/science/add_edexcel/chemical_reactions/rates/quiz/q63137499/
http://pslc.ws/fire/howwhy/triangle.htm
http://www.bing.com/images search?q=Collision+Theory+of+Chemical+-Reactions& Form=IQFRDR#view=detail&id=F1991A8C 155EB-0FABE1D598B0 507B71895F 5DE2A&selectedIndex=12
http://www.bing.com/images search?q=Activation+energy&go=&qs=n&-form=QBIR &pq=activation+energy&sc=8-17&sp=-1&sk=#view=de-tail&id=C4330F FCC22298D71798C4462372111054F635D6&selecte-dIndex=96
http://sun.menloschool.org/~dspence/arda/chem_project/web_wan/fertilizer2.htm
http://wps.prenhall.com/wps/media/objects/3082/3156859/blb1404/bl14fg16.jpg(accessed: Oct. 29, 2014)
http://iytimg.com/vi/OkGzaSOkyf4/maxresdefault.jpg (accessed: Oct. 29, 2014)
https://www.chem.tamu.edu/class/majors/tutorialnotefiles/factors.htm (accessed: July 4, 2014)
http://www.connecticutvalleybiological.com/acid-rain-and-the-environment-acidity-and-plant-growth-p-15860.html
http://envis.tropmet.res.in/menu/ENVIS_Acid_Rain/images/acidImage/Acid_Rain_Arriving.png

Unit 4
MODULE
3

Suggested time allotment: 12 hours

BIOMOLECULES

I. Introduction

Think about the food you eat everyday. Different types of food give you different nutrients for energy, growth and repair. These were introduced to you when you were at the elementary grades. Also, in Grade 9, you have learned that the bonding characteristics of carbon result in the formation of larger variety of compounds.

In this module, you will learn more about compounds which are essential to life. These compounds belong to four main classes of biomolecules: carbohydrates, lipids, proteins, and nucleic acids. Carbohydrates and lipids are generally made up of carbon, hydrogen and oxygen. Proteins and nucleic acids and some derivatives of carbohydrates and lipids also contain nitrogen. You will also have the opportunity to test food for the presence of biomolecules.

At the end of Module 3, you will be able to answer the following key question.

- What differentiates the biomolecules from each other?

II. Learning Competencies/Objectives

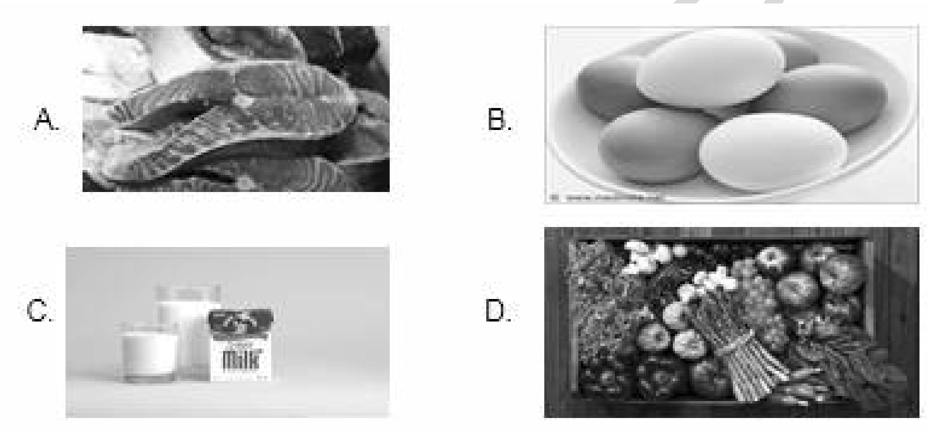
At the end of this module, the learners are expected to:

- Recognize the major categories of biomolecules such as carbohydrates, lipids, proteins and nucleic acids;
- Differentiate the biomolecules from each other in terms of their structure and function.

III. Pre-Assessment

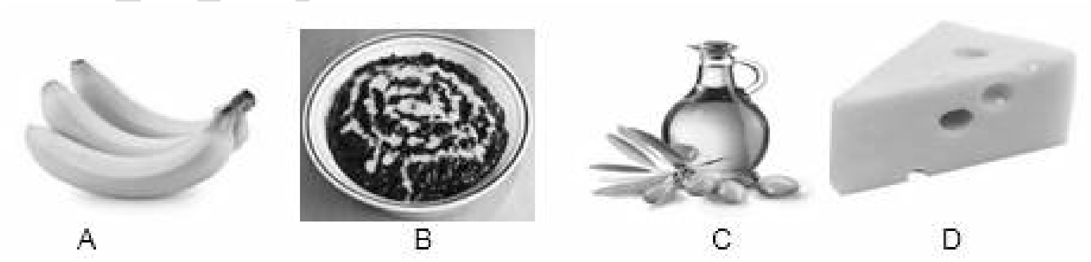
Direction: Analyze each question carefully then choose the letter of the correct answer.

1. Which of the following is NOT a major source of protein?



A. fish B. egg C. milk D. vegetable

2. Which of the following contains the most lipids?



A. banana B. champorado C. olive oil D. cheese

3. Which of the following is a correct pair?
   A. glucose: disaccharide
   B. sucrose: monosaccharide
   C. starch: polysaccharide
   D. triglyceride: polysaccharide

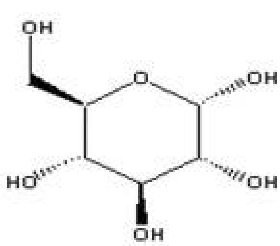
4. Which is a correct pair of an example of protein and its function?
   A. enzymes: speed up reactions in the body and eventually used up in the process.
   B. collagen: provides strength and flexibility to connective tissues.
   C. actin and myosin: supplies amino acids to baby mammals
   D. hemoglobin: helps regulate blood sugar levels

5. Maria wanted to determine what types of biomolecules are present in the three unknown substances that her teacher gave her. The following table shows her results.

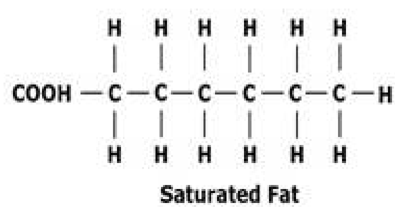
Substance	Iodine Test	Biuret Test	Benedict's Test
A	Black solution (+)	(-)	(-)
B	(-)	(+)	(-)
C	(-)	(-)	(+)

Which of the following statements is TRUE?
   A. Substances A and B are proteins while substance C is a lipid.
   B. Substance A contains starch and substance B and C contain nucleic acid
   C. Substances A and C are carbohydrates where A is an amylose in starch and B is a protein and C maybe a simple sugar
   D. Substance B is a carbohydrate and substances A and C are lipids

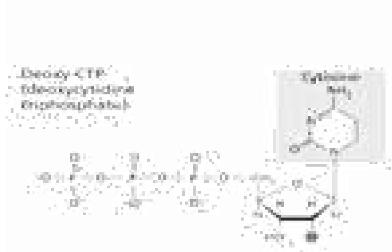
For numbers 6 to 9 please refer to the structures below:



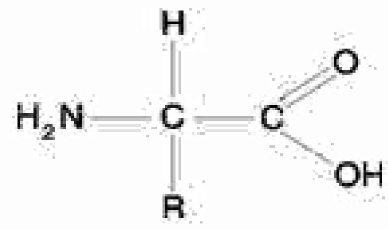
A



B



C



D

6. Which of the given structures (A, B, C, or D) represents molecules that provide energy and are very soluble in water?

7. Which of the given structures (A, B, C, or D) represents hydrophobic molecule that is used as storage of energy?

8. Which of the given structures (A, B, C, or D) represent the molecules that store the hereditary traits of humans?

9. Which of the given structures (A, B, C, or D) represent the building blocks of bigger molecules necessary for structural integrity of organisms?

10. Which of the biomolecules contain other elements aside from carbon, hydrogen, and oxygen?
    A. carbohydrates, lipids
    B. proteins, lipids
    C. nucleic acids, proteins
    D. nucleic acids, lipids

IV. Reading Resources and Instructional Activities

Figure 1. These are foods rich in carbohydrates and lipids

Look at the pictures above. Which food can be classified as carbohydrates or lipids? In order to find out between carbohydrates and lipids, you can perform Activity 1.

Activity 1

Test for Carbohydrates and Lipids

Objective:

- To detect the presence of carbohydrates and lipids in food samples using chemical tests.

Materials:

- Iodine solution or tincture of iodine
- Benedict's solution
- food samples for testing carbohydrates (cooked pasta, cracker,
- cooked rice, corn syrup, table sugar, pineapple)
- food samples for testing lipids (oil, peanut butter, egg, fried chicken,
- butter, milk, burger)
- 6 pcs.small test tubes or vials per group
- 6 pcs. test tube holders per group
- 2 pcs.droppers per group
- mortar & pestle per group
- 1 spot plate per group

Take Care !

1. You must wear goggles and lab gown at all time.
2. Put each test sample in a test tube dedicated for that sample only. If you use oil, wash the glassware with liquid soap for washing to prevent the accumulation of scum.
3. Do not switch the droppers from one reagent bottle to another reagent bottle.

Procedure:

A. Carbohydrates

<u>Iodine Test for Starch</u>

1. Place ½ teaspoon of each food sample on the well of a spot plate. Make sure that the food samples are far from each other.
2. Add 3 drops of Lugol's Iodine solution or tincture of iodine on each food sample.
3. Note that Lugol's iodine solution or tincture of iodine changes from yellow to blue or black in the presence of starch.
4. Write your observation in Table A.

B. <u>Benedict's Test for Reducing Sugar</u>

1. Place a pinch of the food samples to be tested into a test tube.
2. Add 1 full dropper of Benedict's solution to each test tube.
3. Gently shake the test tube or vial.
4. Place the test tubes in the hot water bath for 2-3 minutes. After 2-3 minutes, return the test tubes to the test tube racks. If the substance in your test tube contains sugar, Benedict solution will change color.

Positive Test: Benedict's solution changes from blue to green (very small amount of reducing sugar), to yellow (higher amount of reducing sugar) to orange or brick red (highest amount of reducing sugar). The change in color is due to the formation of the brick red precipitate, Cu_2O.

CAUTION: Always use a test tube holder to handle hot test tubes.

5. Observe your test tube (using white paper as a background). Record the amount of sugar present in Table 1.

Amount of Sugar in Food	0 None	+ Trace	++ Little Sugar	+++ Moderate Sugar	++++ Much Sugar
Color	Blue	Blue green	Green	Yellow	Orange/Red

C. Ethanol Emulsion Test for Fats and Oils

Adapted:http://brilliantbiologystudent.weebly.com/ethanol-emulsion-test-for-lipids.html
(accessed: July 15, 2014)

Solid sample:

1. Crush a pinch of food sample and place in a dry test tube.
2. Add ethanol to about 2 cm^3 above the level of the sample and shake thoroughly.
3. Allow the solid to **settle for** about 3 minutes and decant the ethanol into another test tube.
4. Add 2 cm^3 of **distilled water** to the test tube.
5. Write observations in Table 2.

Liquid sample:

1. Add a **few drops** of the liquid food sample to a dry test tube.
2. Add 2 cm^3 **ethanol** and shake it thoroughly
3. Add 2 cm^3 of **distilled water**.
4. Write observations in Table 3.

Test for Carbohydrates and Lipids

Table 2. Results of Carbohydrate Test

Food Sample	Test for Simple/ Reducing Sugars/ Benedict's Test	Iodine Test
Cooked pasta		
Cracker		
Cooked rice		
Corn syrup		
Table sugar		
Pineapple		

Table 3. Results of the Ethanol Emulsion Test for Lipids

Food Sample	Colorless	Layer of Cloudy White Suspension
Oil		
Peanut Butter		
Egg		
Fried Chicken		
Butter		
Milk		
Burger		
Mashed potato		

Q1. Which of the foods samples tested would your body use for a quick burst of energy?
Which could be used for energy when no carbohydrates are available?

Q2. Why it is that Benedict's test gives a negative (-) result with sucrose or table sugar?

Q3. What kind of foods rich in fats should be taken in moderation? Why?

Carbohydrates

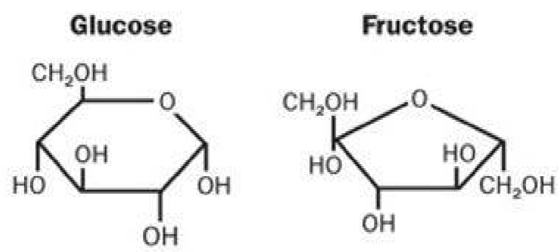
Since food is always a part of our lives it is important that we know the nutrients found in the food we eat. The following discussions will give you a clearer avenue to understand carbohydrates.

Figure 2. Foods rich in carbohydrates

Figure 2 shows some foods that are rich in carbohydrates. Carbohydrates are the major source of energy for the body. These are simple sugar, starch and cellulose. All carbohydrates contain carbon, hydrogen, and oxygen. They may be classified into the following:

Monosaccharides

From the prefix "mono" which means one, monosaccharide is the simplest sugar and the basic subunit of a carbohydrate.These compounds are white solids at room temperature. Because they have polar, hydroxyl (-OH) groups in their molecular structures, they are very soluble in water. The most common monosaccharides are **glucose** (also called dextrose) and **fructose**.



http://joelbergerdc.com/tag/glucose-vs-fructose/
Figure 3. Structure of Glucose and Fructose

Although both of these monosaccharides have the formula $C_6H_{12}O_6$, their structural formulas differ. As figure 3 shows, glucose in water solution forms a ring made up of five carbon atoms and one oxygen atom, and fructose in a water solution forms a ring made up of four carbon atoms and one oxygen atom. Both compounds have five-OH groups in their structures.

Compounds with the same molecular formulas are called **isomers.** So, glucose and fructose are isomers. Though they have the same molecular formula, these sugars cannot be used in the same way by cells in the body. The arrangement of the C, H, and O atoms determines the shape and properties of each sugar.

In Grade 8, you have learned about how carbohydrates and proteins are broken down in digestion. For fats and lipids, their digestion is completed in the small intestine and is broken down primarily into fatty acids and glycerol.

During digestion, carbohydrates are broken down into monosaccharide which is absorbed into the blood and transported to the cells providing “instant” energy to perform our activities. Sometimes we eat too much, especially when we are tired, the excess glucose is stored in the liver as **glycogen** for later use. It is very important to have a steady supply of glucose in the blood to maintain body functions. As what they say, too much or too little of anything may lead to some diseases. When too much glucose is in the blood, the pancreas secrete a hormone called insulin which stimulates cells in the liver, muscles and fat to absorb glucose and transform it into glycogen or fats, which can be stored for a period of time. When blood glucose drops, the pancreas secretes glucagon, which causes the liver, muscles and fat to convert glycogen back to glucose.

Fruits like grapes, apple or atis contain a monosaccharide called fructose or fruit sugar.It is considered the sweetest naturally occurring sugar.Due to its sweetness, fructose is sometimes used as a low calorie sweetener because less fructose is needed to produce the same sweetness that table sugar does. Starchy food that we eat is widely distributed in the plant world.Thus, its main constituent glucose is found in all plants and in the sap of trees.However, glucose is also found in glycogen that is produced in animal cells.

Disaccharides

In the morning, Aaron Jay’s mother prepares his coffee; he always adds half a teaspoon of table sugar. He remembered his TLE (Technology and Livelihood Education) teacher who mentioned one time in their class that the sugar we use to sweeten coffee is a disaccharide. It is also called sucrose with the molecular formula $C_{12}H_{22}O_{11}$. He wondered how sucrose, which is disaccharide, is formed. In their chemistry class, their teacher explained that the formation and breakdown of sucrose to glucose involves two reactions.

Condensation reaction is a reaction in which two molecules or parts of the same molecule combine. During the condensation of monosaccharides to form disaccharides, one molecule of water is lost.When two glucose molecules are combined, maltose is formed and water is lost during the process. A **Hydrolysis reaction** occurs when the bond between monosaccharides is broken with the addition of a water molecule.

Q1. What is the name of the dissacharide found in cheese and other milk products?

After he finished doing his homework, Aaron Jay drinks his milk. When he is about to jump into his bed to have a good night sleep, he has this bloated feeling along with a build up of intestinal gas.He feels uneasy and cannot sleep. He swears he will never drink milk again! The following morning in his chemistry class, his teacher discussed another important disaccharide- Lactose or milk sugar. Lactose is made up of a sugar called **galactose** and **glucose**. In our body, a specific enzyme, **lactase** is necessary to help break the bond between the two monosaccharides when lactose is digested.

People who cannot digest milk products are called “lactose intolerant” because they do not produce the enzyme (lactase) necessary to break the bond between glucose and galactose. Since lactose molecules are too large to be absorbed into the circulatory system, they continue through the digestive system, where they are eventually broken down by bacteria in the large intestine. These bacteria digest monosaccharides, producing carbon dioxide gas in the process. As a result, a common symptom of lactose intolerance is a build up of intestinal gas along with a bloated feeling, and more often the passing out of undigested lactose as diarrhea. After the discussion, he concluded that he maybe “lactose intolerant.”

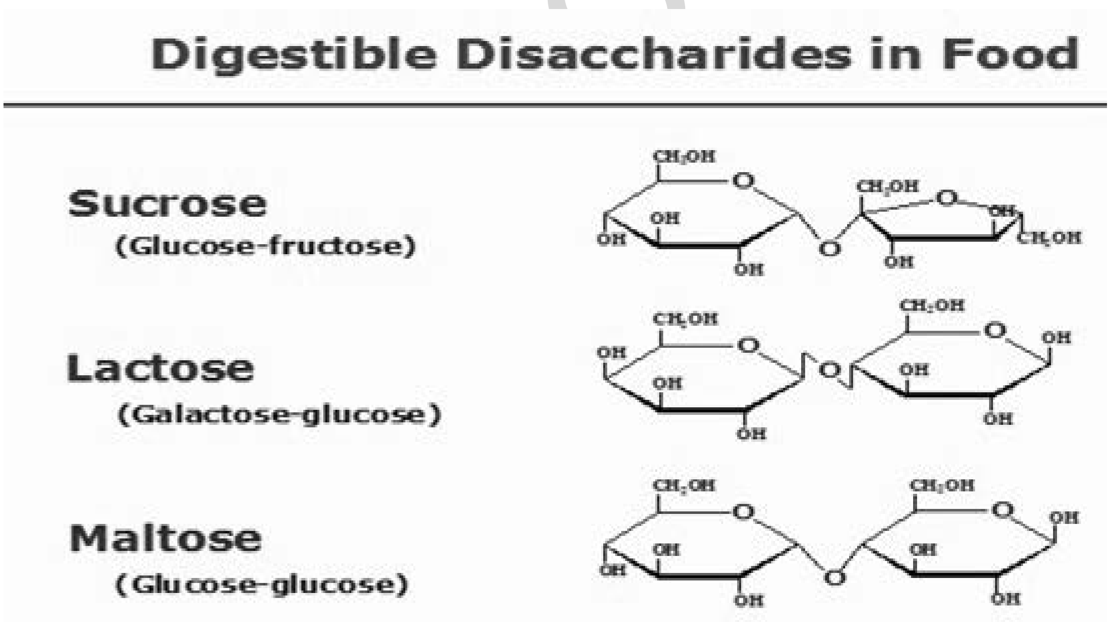


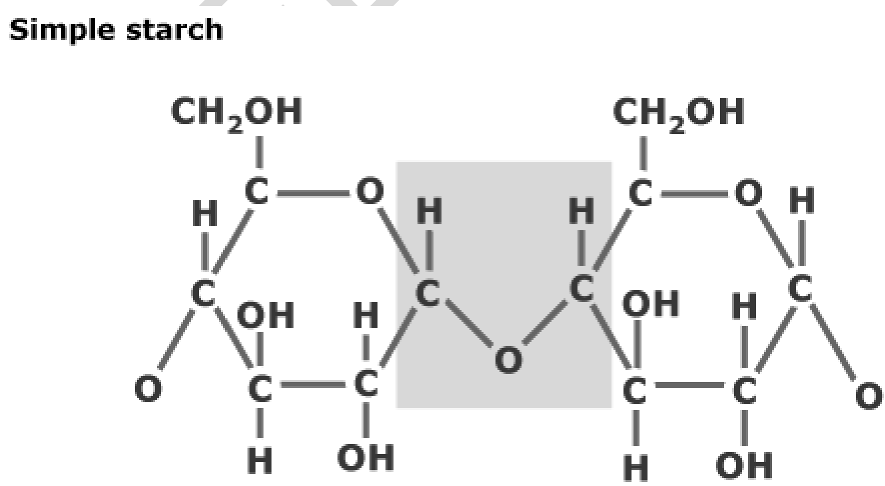
Figure 4. Structure of Disaccharides

Figure 4 shows that when two monosaccharides join together by combination reaction, a glycosidic bond will be formed between the two monosaccharide molecules. The reaction produces water as a side product.

Polysaccharides

In the evening, he did not drink milk anymore. Instead he ate fruits before going to bed. The following morning he had the same routine-ate his breakfast and went to school. As the bell rang, Aaron Jay rushed to the canteen to eat his lunch. It included local tubers like sweet potato or camote and green, leafy vegetables like *malungay* and *kangkong*. Again, he remembered the result of their activity no.1 wherein the food samples like sweet potato and ripe banana turned blue-black when stained with iodine solution. In their class discussion, these foods contain polysaccharides (the prefix poly means many) or complex carbohydrates. They are large molecules that are made up of many smaller units that are joined together.The reason why these foods turn blue-black is because they contain starchy components. After lunch, he returned to their classroom.Their discussion was about the three common polysaccharides- **starch**, **glycogen,** and **cellulose**.

The breakdown of **starch** requires a water molecule to provide a hydrogen atom and a hydroxyl group to the site where the bond is broken. With the help of enzymes in the digestive system, the glucose units can be separated from one another. When a glucose molecule is separated from the rest of the starch polymer; it can be absorbed and used as fuel by your cells. Since it takes time for glucose to be separated from the polysaccharide, it is released to the cells gradually. Thus, the glucose from starch reaches muscle cells over a period of time providing energy as it is needed. For this reason, athletes often eat meals rich in complex carbohydrates before an athletic event.

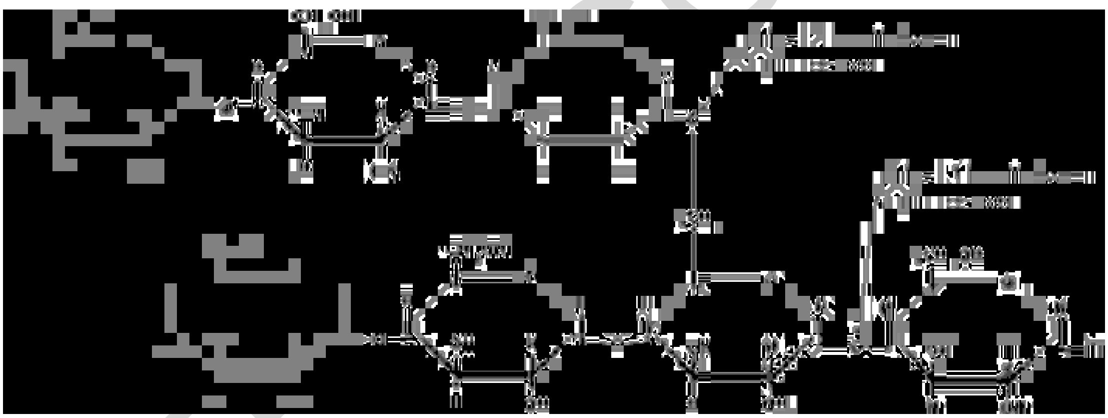


https://courses.ecampus.oregonstate.edu/ans312/one/carbs_story.htm
Figure 5. Structure of Starch

Starch is the chief storage form of carbohydrates in plants and the most important source of carbohydrate in human nutrition. A starch molecule is a polysaccharide assembled from the simple sugar **glucose;** it can contain anywhere from five hundred to several hundred thousand glucose molecules joined by **covalent bonds** into a single structure. Starch is made up of two types of polysaccharides: amylose, which is a coiled or helical structure, and amylopectin, which is branched. Plants make starch.

All individuals whose intake of glucose is excessive will store the excess glucose as fat for long term storage and some are converted to another polysaccharide **glycogen**. Glycogen is a polysaccharide that is similar to starch because it is also composed of alpha glucose units. It differs from starch since glycogen shows a higher degree of branching and is a polysaccharide that is made by animal.

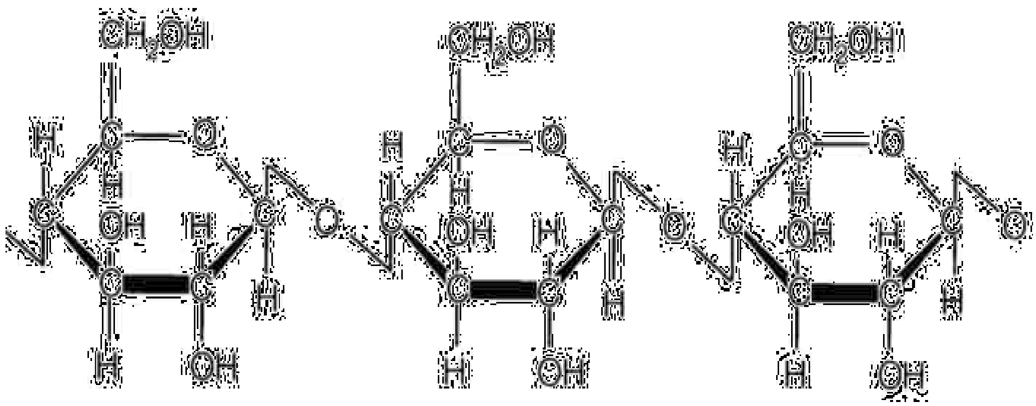
On the other hand, starch contains both straight chain and branched polysaccharides with much less branching than that of glycogen, and is made only by plant.



http://www.natuurlijkerwijs.com/english/Glycogen_metabolism.htm
Figure 6. Structure of Glycogen

Figure 6 shows the structure of glycogen which consists of long polymer chains of glucose units connected by an **alpha glycosidic** linkage.It is a multibranched polysaccharide of glucose that serves as a form of energy storage in animals. The polysaccharide structure represents the main storage form of glucose in the body

Glycogen is the readily available energy stored in liver and muscles and the one that is easily metabolized. Fats are stored in adipose tissues but unlike glycogen, are not as readily metabolized. They are used during prolonged exercise or activity.



https://myorganicchemistry.wikispaces.com/
Cellulose?responseToken=1a9131f668de1a94603bbdfb79f69128
Figure 7. Structure of Cellulose

The glucose molecules in **cellulose** chains (refer to Figure 7) are arranged in such a way that hydrogen bonds link hydroxyl groups of adjacent glucose molecules to form insoluble fibrous sheets. These sheets of cellulose are the basic component of plant. People cannot digest cellulose, but when we eat foods rich in fiber, which is cellulose, it speeds the movement of food through the digestive tracts. It is a food for herbivorous animals like cows, carabaos, goats, and horses. These animals have microorganisms in their digestive tracts that can digest cellulose. They have a special stomach chamber that holds the plants they eat for a long period of time, during which these microorganisms can break down the cellulose into glucose. The protozoans in the gut of insects such as termites also digest cellulose.

Being of great economic importance, cellulose is processed to produce papers and fibres, and is chemically modified to yield substances used in the manufacture of items such as plastics, photographic films, and rayon. Other cellulose derivatives are used as adhesives, explosives, thickening agents for foods, and in moisture-proof coatings.

Likewise, starch has many industrial applications in addition to its importance in human nutrition. It is used in the manufacture of paper, textiles, pharmaceuticals, and biodegradable polymers, and as an additive in foods.

Formulative Assessment:

Q2. Why do you think marathon runners eat a meal rich in carbohydrates the day before the race?

After the discussion, Aaron Jay was amazed at how carbohydrates contribute to energy production and the manufacture of important products for human consumption.

Lipids

In the previous lesson, you have learned that carbohydrates are important in providing "instant" energy for cells. There is another class of biomolecules called **lipids** that have the "job" of storing energy for later use. Lipids are also found in hormones and cell membrane components.

Foods rich in lipids

Lipids have different structural types such as carboxylic acids or fatty acids, triglycerides or neutral fats, steroids, and waxes, to name a few. Naturally occuring esters are lipids that contain one or more long-chain carboxylic acids called **fatty acids**. These are insoluble in water but soluble in nonpolar solvents.

When Aaron Jay accidentally mixed oil and water he observed that they do not mix. He was late in his Chemistry class the following morning but he was able to catch up the discussion of his teacher on lipids. His teacher explained that oil and water do not mix because they do not have the same polarity. Also, oils are composed primarily of long hydrocarbon chains. They are formed reaction between an alcohol and one or more long–chain carboxylic acids.

The most abundant of the lipids are the **fats** and **oils**, also called triglycerides. Table 4 below shows the structures of common fatty acids. The presence of double bonds in the fatty acids lowers its melting point. At room temperature, lauric acid is solid while linoleic acid is liquid.

Table 4. Structures of Some Common Fatty Acids

Name	Structural Formula	Melting Point (°C)
Lauric	$CH_3(CH_2)_{10}COOH$	44
Myristic	$CH_3(CH_2)_{12}COOH$	53
Palmitic	$CH_3(CH_2)_{14}COOH$	63
Stearic	$CH_3(CH_2)_{16}COOH$	70
Oleic	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$	16
Linoleic*	$CH_3(CH_2)_4(CH{=}CHCH_2)_2(CH_2)_6COOH$	-5
Linolenic*	$CH_3CH_2(CH{=}CHCH_2)_3(CH_2)_6COOH$	-11
Arachidonic*	$CH_3(CH_2)_4(CH{=}CHCH_2)_4(CH_2)_2COOH$	-50

Source: Padolina, M.C.D., Antero, E.S., Alumaga, M.J.B & Estanilla, L.C. (2004). Conceptual and Functional Chemistry

Fats are solids at room temperature and contain saturated fatty acids. Aaron Jay still remembered that all saturated hydrocarbons contain single bonds and they are produced only by animals. Examples of animal fats are lard and butter.

Oils are liquids at room temperature and contain unsaturated fatty acids. Again, he recalled that unsaturated hydrocarbons contain one or more double bonds. Most oils, such as vegetable oil, corn oil, and olive oil are produced by plants. Table 5 gives the fatty acid content of some glycerides.

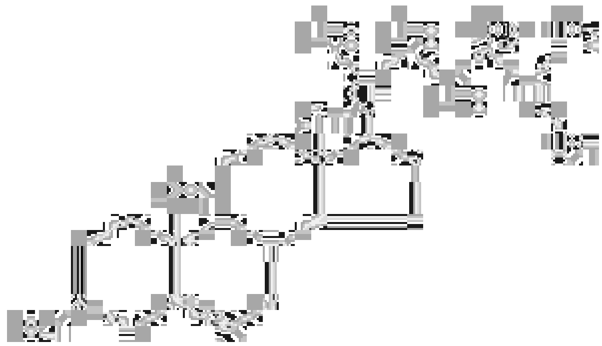
Table 5. Fatty Acid Content of Some Triglycerides

Source		Saturated			Unsaturated		Others
		Myristic	Palmitic	Stearic	Oleic	Linoleic	
Animal Fat	Butter	10	29	9	27	4	31
	Lard	2	30	18	41	6	5
	Beef	3	32	25	38	3	2
Plant Oil	Corn	1	10	4	34	48	4
	Soybean	-	7	3	25	56	9
	Peanut	-	7	5	60	21	7
	Olive	1	6	4	83	7	-

Sometimes we prefer to buy a product in solid form rather than in liquid. Which do you prefer? Spreading margarine on a pandesal or pouring oil on it? Of course, margarine is more acceptable to consumers when it is solid because it looks more like butter. However, margarine is made from vegetable oils that are liquid at room temperature. The oils can be processed to form solid margarine. How is this done?

Can we consider fats good or bad? It depends. If you eat in moderation, fats are good sources of body fuel.They are considered good emergency food and are efficient energy storage system. However, an excess quantity of fats is not good for the heart. The reason why fats are not good for the heart is because they tend to clog arteries and overwork the heart.While carbohydrates are the main source of energy in your body, your system turns it to fat as a backup energy source when carbohydrates are not available. Vitamins A, D, E, and K cannot function without adequate daily fat intake since they are fat soluble vitamins. If you don't meet your daily fat intake or follow a low fat diet, absorption of these vitamins may be limited resulting in impaired functioning.

Steroids are another class of lipids whose molecules are composed of fused rings of atoms. The most important steroid is **cholesterol.** It is a sterol because of the presence of alcohol or the hydroxyl functional group.It is found mainly in animal cells although cell membranes of plants may contain small quantities of cholesterol as well as its major derivatives, sitosterol.



http://sphweb.bumc.bu.edu/otlt/MPH-Modules/PH/PH709_BasicCellBiology/PH709_BasicCellBiology24.html

Figure 11. Structure of Cholesterol

Figure 11 shows the unique structure of cholesterol which consists of four linked hydrocarbon rings forming the bulky steroid structure. There is a hydrocarbon tail linked to one end of the steroid and a hydroxyl group linked to the other end. Cholesterol is known as a "sterol" because it contains an alcohol functional group-OH. Cholesterol is present in most animal membranes with varying amounts but is absent in prokaryotes.

Cholesterol plays an important role in eukaryotes and especially abundant in cell membranes of animal cells. Small amount of cholesterol can also be found in the membrane of some organelles inside the cells, such as the mitochondrion and the endoplasmic reticulum. It is not only abundant in cell membrane, but also in brain tissues of the nervous system. An important nerve cell, myelin, covers nerve axons to help conduct the electrical impulses that make movement, sensation, thinking, learning, and remembering possible. Studies have shown that cholesterol was found to be the most important factor in the formation of synapses, which greatly affect our memory and learning ability. Animals are able to use cholesterol to synthesize other steroids like cortisone, testosterone, and estrogen. These hormones are already discussed in Grade 9. Although cholesterol is an essential lipid for humans, excessive levels of cholesterol in the blood can lead to deposits in the arteries of the heart. These arterial deposits are a leading cause of heart disease. (LeMay Jr, 2000)

Aaron Jay's journey to the world of carbohydrates and lipids gave him a clearer view of the importance of these biomolecules in providing the body with energy. However, he still wants to know which type of molecule has the higher calorie content.

His teacher explained that a calorie is actually a unit of heat energy. We think of calories as something that are present in food and all food have calories. However, your body sees calories as energy in the form of heat. Heat energy is what really fuels our body in the same way that gasoline fuels your car's energy.

Now all foods have calories and different foods have different amounts of calories. Calories are provided by fats, carbohydrates, and proteins. Fats have the highest concentration of calories.On the average, that's nine calories per gram of pure fat. Proteins and carbohydrates each have four calories per gram of pure protein or pure carbohydrate on the average. So understanding the role of calories in your diet can help you balance your calories in with your calories out, and help you achieve weight management goals.

On the sample Nutrition Facts label, the serving size of this food is 1 cup and there are 2 servings in this container. There are 260 calories per serving of this food. If you eat the entire container of this product, you will eat 2 servings. That means you double the calories (260 x 2= 520 calories) If you eat 2 servings, you will have eaten over 500 calories.

Nutrition Facts

Serving Size 1 cup (228g)
Servings Per Container 2

Amount Per Serving	
Calories 260	Calories from Fat 120
	% Daily Value*
Total Fat 13g	**20%**
Saturated Fat 5g	**25%**
Trans Fat 2g	
Cholesterol 30mg	**10%**
Sodium 660mg	**28%**
Total Carbohydrate 31g	**10%**
Dietary Fiber 0g	**0%**
Sugars 5g	
Protein 5g	

Vitamin A 4% • Vitamin C 2%
Calcium 15% • Iron 4%

*Percent Daily Values are based on a 2,000 calorie diet. Your Daily Values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

Sample Nutritional Label

Retrieved: http://www.health.gov/dietaryguidelines/dga2005/healthieryou/html/chapter5.html

Q3. Carbohydrates and lipids are composed of the same chemical elements, but in diffeent proportions. Both are used primarily as energy sources for cell metabolism. Which type of molecule has the higher calorie content per gram? Explain the reasons for your answers.

Wait! You still need to explore another activity to enhance your knowledge on the identification of protein present in foods.

Activity 2

A. Test for Proteins

Objectives:

- Perform standard chemical test for proteins.
- Relate indicator reactions to the presence of organic nutrients.

Materials:

- 0.5 M sodium hydroxide solution
- 0.5 M copper (II) sulfate solution
- droppers
- test tubes
- test tube racks
- food samples (egg white, cooked fish, cooked meat, cooked legumes, taho)

Procedure:

<u>Biuret Test</u>

1. Place a pinch of food sample to be tested into a test tube.
2. Add 5 drops of NaOH and 5 drops of $CuSO_4$ solution to the test tube.
3. Gently shake the test tube.
4. Observe the content of each test tubes (using white paper as background). If the food contains protein, it will turn pink or blue- violet. Record the amount (0, +, ++, +++, ++++) of proteins for each food substance in table C.

Positive Test: Biuret is clear or light blue in the absence of protein and pink or blue-violet in the presence of protein.

Amount of Protein in Food	0 None	+ Trace	++ Little protein	+++ Moderate protein	++++ Much protein
Color	Light Blue	Light pink	Pink	Blue-violet	Dark blue-violet

CAUTION: Biuret reagent can burn your skin. Wash off spills & splash immediately with plenty of water.Inform the teacher when this occur.

Data/Results

Table C

Food Samples	Biuret Test
egg white	
cooked fish	
cooked meat	
cooked legumes	
taho	

Q4. Describe what you observed in each test tube.

Q5. Which foods may be used for building body parts?

B. The Denaturation of Proteins

Adapted from Sourcebook on Practical Work for Teacher Trainers, High School Chemistry volume 2, UP-NISMED

Objectives:
- Identify the agents for the denaturation of proteins.
- Relate the denaturation of proteins to home or ordinary activities.
- Explain what happens to proteins upon denaturation.

Materials:
- dilute egg white solution
- 0.1 M copper (II) sulfate solution
- conc. HCl
- ethanol
- test tubes
- dropper
- alcohol burner

Procedure:

1. Set up four test tubes (labeled A, B, C, and D) in a test tube rack. Place about 2 cm^3 of the egg white solution in each test tube. Add a few drops of each of the following reagent solutions to separate egg white samples in test tubes A, B, and C.
   A. 0.1 M Copper(II) sulfate solution
   B. conc. HCl
   C. ethanol

Take Note: Preparation of egg white sample: Mix together one portion of egg white with five portions of water in a small beaker. Add a very small amount of sodium chloride.

Observe what happens in each test tube.

Q6. Describe what you observed in each test tube.

Q7. Copper sulfate is used as a fungicide in the garden. Explain the relation of this application to what you have just observed.

Q8. A 70% solution of ethanol in water is used as a disinfectant. Explain the basis for this application.

2. Get test tube D and apply heat. Observe any change.

Q9. Describe what happens.

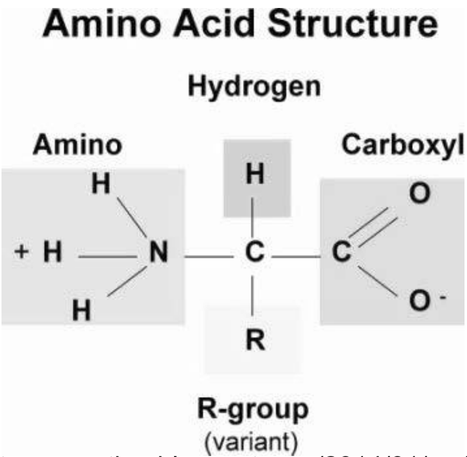
Q10. Give other examples of ordinary activities at home that involve the denaturation of proteins.

Proteins

Proteins are made up of the elements carbon, hydrogen, oxygen, nitrogen and sulfur. Let's continue the story of Aaron Jay on his journey this time to the world of proteins. From the result of his activity, he was able to know that egg white, fish, meat, and cheese are foods rich in proteins. He learned from their discussion that proteins are found in all living cells.They are the second most common molecules found in the human body (after water) and make up about 10% to 20% of the mass of a cell. So whenever Aaron Jay eats protein-rich foods, his digestive system breaks the long protein chains into simpler substances called **amino acids.** He learned from his Chemistry class that amino acids are the building blocks of proteins. Of the 20 amino acids found in human protein, only 11 can be synthesized by the body and 9 have to be supplied by the foods we eat. These 9 amino acids are also called **essential amino acids**. Adults only need to obtain eight of them: valine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine and tryptophan. The ninth amino acid - histidine - is only essential for infants. Your body doesn't store amino acids, so it needs a regular daily supply of these essential building blocks. Nonessential is a slightly misleading label because these amino acids actually fill essential roles, but since they're synthesized by your body, they're not an essential part of your diet. Of the 11 nonessential amino acids, eight are called conditional amino acids. When you're sick or under significant stress, your body may not be able to produce enough of these amino acids to meet your needs. The list of conditional amino acids includes arginine, glutamine, tyrosine, cysteine, glycine, proline, serine, and ornithine. The remaining three - alanine, asparagine, and aspartate - are nonessential.

Aaron Jay also learned that whenever he eats protein foods, he is supplied with amino acids for the rebuilding of his body system.



http://entrytest-preparation.blogspot.com/2014/01/amino-acids.html
Figure 12. Structure of amino acid

Figure 12 shows the structure of amino acids. Amino acids are organic molecules that contain two functional groups: a basic NH_2 amino group and an acidic- COOH carboxylic acid group.

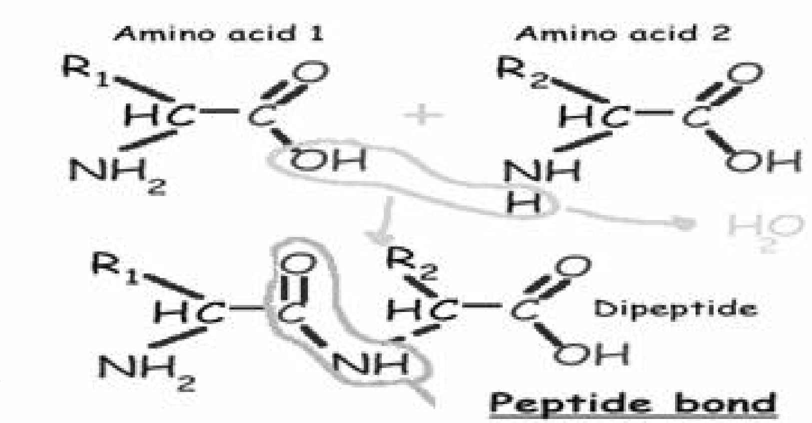


Figure 13. Peptide Bond

When two amino acids react with each other in an acid-base reaction, a peptide is formed. The basic amino group of one amino acid reacts with the acidic carboxylic group of another amino acid, forming the peptide, and a molecule of water is lost. This reaction shown above is classified as a condensation reaction because the two amino acid molecules join together and water is formed. The bond formed is called a peptide bond, and the product is a dipeptide because it is made up of two amino acid units. Longer chains are called polypeptides and chains of 50 or more amino acids are called proteins.

After the discussion on essential & non essential amino acids, Aaron Jay's teacher discussed the primary, secondary, tertiary, and quarternary structures of proteins.

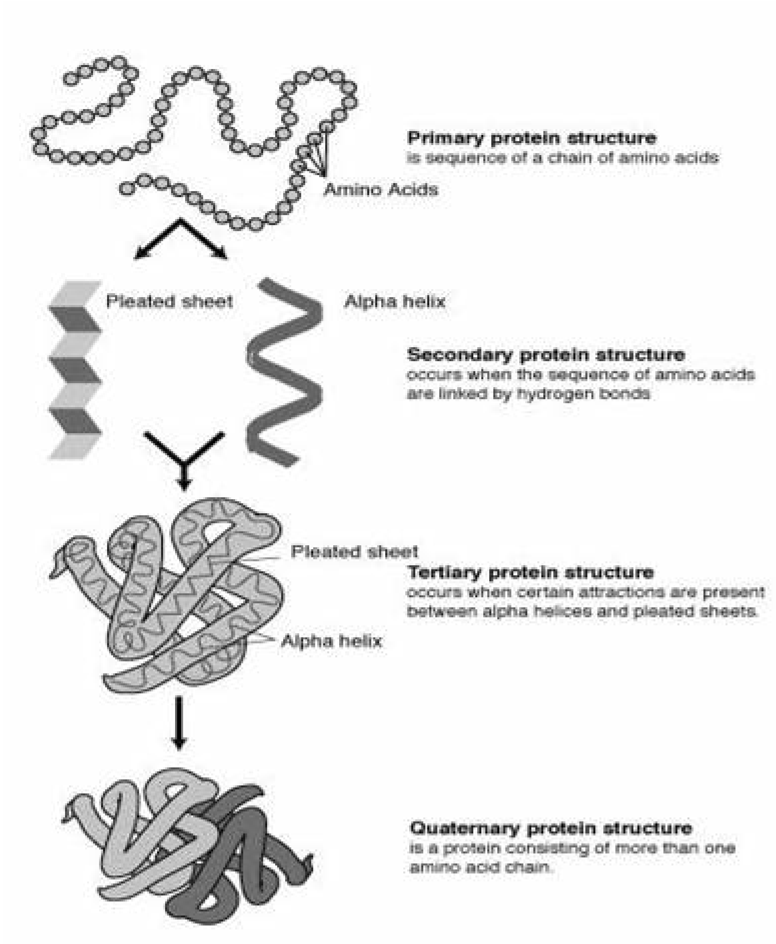


Figure 14. Primary, Secondary ,Tertiary, and Quaternary Proteins

Proteins are characterized by their primary, secondary, tertiary and quaternary structures.The kind of amino acids, which make up the chain, the sequence in which the amino acids are arranged and the length of the chain distinguishes the primary structure of proteins. The secondary structures of proteins refer to the coiling of the protein chain into a α–helix structure, formation of b sheets, or twisting into random structures. These structures are the results of interactions between R groups, H-bonding or formation of –S-S- bonds between chains. Protein molecules are so long that they automatically coil, fold or twist. The resulting shape is unique for each polypeptide in a particular medium, at a particular pH. The tertiary structure describes the shape of the coiled chain when it is folded or hydrated in its natural state. (Adapted: Practical Work for Teacher Trainers, High School Chemistry volume 2, UP-NISMED)

The quaternary protein structure involves the clustering of several individual peptides into a final specific shape. A variety of bonding interactions including hydrogen bonding, salt bridges and disulfide bonds hold the various chains into a particular geometry.

Proteins perform varied functions in the body. How they perform their functions depend on their composition and structures. The particular form and shape each protein molecule takes determines or dictates its function within the organism. Aaron Jay remembered the result of their activity on denaturation of protein. When denaturing agents change the secondary and tertiary structures of proteins, the protein functions are impaired.

The protein molecules in egg white fold and aggregates, which dissolve in water. The long string of molecules unfolds once it is denatured by such agents as heat, salt, baking soda, rubbing alcohol, etc.

From the results of the activity 2, Aaron Jay learned that denaturation finds many applications at home. An example is the extraction of oil from coconut milk emulsion (gata). Proteins act as the emulsifying agent. When the coconut milk emulsion is heated, oil separates from water and is then recovered. The tasty solid residue remaining (latek) after water evaporates is denatured protein. Also, the preservation of food by pickling and salting also involves denaturation of proteins. Vinegar and salts are agents for denaturation. Decay microorganisms are killed when their cell proteins are denatured. (Adapted: Practical Work for Teacher Trainers, High School Chemistry volume 2, UP-NISMED)

Aaron Jay also learned that protein malnutrition, also known as Kwashiorkor, affects children in underdeveloped countries.Although protein malnutrition can be classified as a type of malnutrition; protein malnutrition usually goes hand in hand with calorie malnutrition and referred to as Protein-Energy Malnutrition (PEM).

Another type of protein is the **enzymes.** It is known as biological catalysts. In Grade 8 biology, you have learned the amazing action of catalysts particularly during digestion process.These molecules speed up biochemical reactions without themselves being used up in the process. They are also highly specific. That is, they act only on certain molecules called substrates (reactants), while leaving the rest of the system unaffected. The role of an enzyme can be compared to a lock and a key. The lock will not open unless you use the right key. In the same manner an enzyme works for a specific substrate like the enzyme **lactase.** Its role is to breakdown the sugar lactose into glucose and galactose. You must appreciate the role of enzymes in the body. Without them, chemical reactions in the body may be too slow to occur at normal condition and may affect the normal functioning of the different systems of the body.

After the discussion on proteins, Aaron Jay was amazed at how diverse this group is and the myriad of functions they possess that are very important to all living things.

NUCLEIC ACIDS

Mother and daughters
Photo credit: Edwin Manalang

Aaron Jay wonders why siblings resemble each other, or how a mother and her daughters look alike. He will discover the answer as he explores the next lesson. Nucleic acids are molecules that code for hereditary traits by controlling the production of protein. Like proteins, nucleic acids are long chain of polymers consisting of simpler units or monomers. There are two kinds of nucleic acids: DNA, or deoxyribonucleic acid; and RNA, or ribonucleic acid. DNA found mainly in the cell nuclei contains the genetic information that codes for the sequences of amino acids in proteins. RNA is found in many places in the cell and carries out the synthesis of proteins.

The monomers of nucleic acids are nucleotides. They are made up of three parts: a five carbon sugar (pentose), a phosphate group, and a ring-shaped base containing nitrogen.

In this model, the sphere represents a phosphate group, the pentagon represents a five–carbon sugar (pentose) and the rectangle represents a nitrogen-containing base.

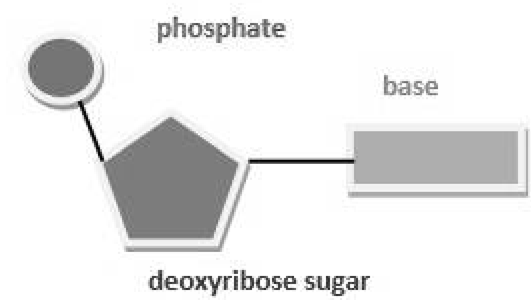


Figure 15. Show a model of a nucleotide.

The double-helix consists of two linear strands of polymerized nucleotides that bound about each other. The two strands are held together by **hydrogen bonds** that form between pairs of nucleotides. Adenine (A) forms hydrogen bonds with a thymine (T) of the other strand. Cytosine (C) forms hydrogen bonds with a guanine (G) of the other strand.

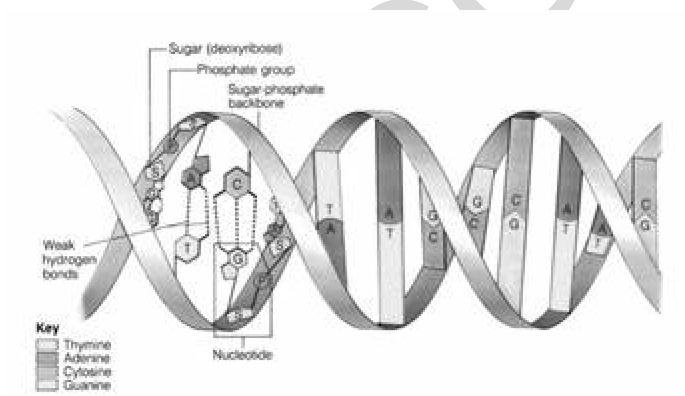


Figure 16. A model of a double helix for DNA

Below is a summary of the differences between the two kinds of nucleic acids: (http://www.diffen.com/difference/DNA_vs_RNA)

	DNA	**RNA**
	Deoxyribonucleic Acid	**Ribonucleic Acid**
Description	It contains the genetic instruction used in the development and functioning of all living organisms.	It is responsible for the template in the synthesis of proteins which in turn control the operation & function of the cell
Function	Long-term storage and transmission of genetic information	Transfer the genetic information for the creation of proteins from the nucleus to the ribosomes
Sugar and Bases	Deoxyribose sugar Phosphate backbone; Four Bases: adenine, guanine, cytosine, and thymine	Ribose sugar Phosphate backbone; Four Bases: adenine, guanine, cytosine, and uracil
Pairing of Bases	A-T (Adenine-Thymine) G-C (Guanine-Cytosine)	A-U (Adenine-Uracil) G-C (Guanine-Cytosine)

The process by which an identical copy of the original DNA is formed is called **DNA replication.** An analogy of DNA replication is opening a zipper.As you open, each side of the zipper acts as a template for the synthesis of a new, complementary strand. The result is two new DNA molecules, which have the same base pair sequence as the original double helix.

Proteins are the ones responsible for observable traits like curly hair, blue eyes, dark skin, etc. DNA and RNA molecules direct the synthesis of proteins in the cells. However, this is beyond the scope of this module.

V. Summary/Synthesis/Feedback (LeMay Jr, 2000)

Carboydrates

- They are molecules made from aldehydes and ketones containing numerous hydroxyl groups.
- Monosaccharides are composed of a single ring.
- Disaccharides consist of two monosaccharides that are chemically combined.
- Polysaccharides are polymers containing numerous monosaccharide monomers.

Lipids

- They are water insoluble molecules that are composed of carbon, hydrogen and oxygen.
- Fats and oils are triglycerides that are combinations of glycerol and three fatty acids.

Proteins

- Proteins are polymers of amino acids. They are found as structural materials in hair, nails and connective tissues.
- Enzymes are proteins that act as biological catalysts.

Nucleic Acids

- Deoxyribonucleic acid (DNA) and Ribonucleic acid (RNA) are nucleic acids.Both DNA and RNA are polymers that are made up of nucleotides.
- Nucleotides are molecules that are composed of three parts: a five carbon sugar, a nitrogen-containing base, and a phosphate group.

Glossary of Terms

- Biomolecule is any molecule that is produced by a living organism, including large macromolecules such as proteins, polysachharides, lipids and nucleic acids.

- Condensation reaction is a process by which two molecules form a bond with the removal of a molecule of water.

- Hydrolysis is a reaction in which water is added to a reactant, breaking the reactant into two product molecules.

- Monomer is a small molecule that joins with other similar molecules to make a polymer; repeating units of a polymer

- Polymer is a large organic molecule consisting of small repeating units called monomers.

VI. Summative Assessment

Direction: Analyze each question carefully then choose the letter of the correct answer.

1. Nutritional chemists have found that burning 1 gram of fat releases twice the amount of heat energy as burning 1 gram of starch. Based on this information, which type of biomolecule would cause a person to gain more weight?
   a. carbohydrate
   b. fat
   c. proteins
   d. nucleic acid

2. Lipids are insoluble in water because lipid molecules are _________?
   a. hydrophilic
   b. neutral
   c. hydrophobic
   d. Zwitter ions

3. Which of the following groups are all classified as polysaccharide?
   a. sucrose, glucose and fructose
   b. maltose, lactose and fructose
   c. glycogen, sucrose and maltose
   d. glycogen, cellulose and starch

4. Amino acids are the building blocks of which group of biomolecules?
   a. proteins
   b. carbohydrates
   c. lipids
   d. nucleic acid

5. Which of the following is the major function of carbohydrates?
   1. structural framework
   2. storage
   3. energy production

   a. 1 only
   b. 2 only
   c. 3 only
   d. 1 & 3 only

6. In which organs are glycogen stored in the body?
   A. liver and spleen
   B. liver and muscle
   C. liver and bile
   D. liver and adipose tissue

7. When digesting a complex carbohydrate, water is added and simple sugar is obtained through which process?
   a. Photosynthesis
   b. Condensation
   c. Hydrolysis
   d. Dehydration

8. What kind of molecule is represented by the structure below?
   $CH_3CH_2CH_2CH_2CH{=}CHCH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2COOH$

   a. monosaccharide
   b. unsaturated fatty acid
   c. saturated fatty acid
   d. phospholipid

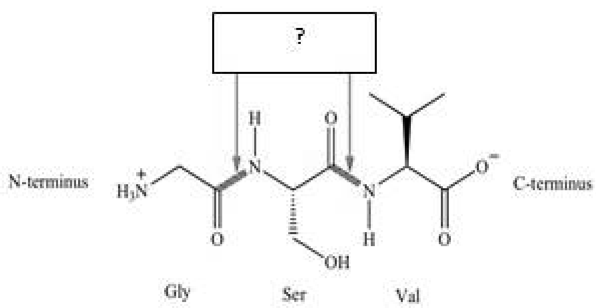
9. Disaccharide is formed by combining two monosaccharides. What do you call the process of combining 2 or more simple sugars?
   a. Hydrolysis
   b. Peptide bonding
   c. Condensation
   d. Saccharide bonding

10. Which of the following elements is NOT present in carbohydrates?
   a. carbon
   b. oxygen
   c. nitrogen
   d. hydrogen

11. Which of the following biomolecules contain only the elements carbon, hydrogen and oxygen?
   a. carbohydrates and lipids
   b. lipids and proteins
   c. proteins and nucleic acids
   d.nucleic acids and carbohydrates

12. Which of the following sugars are the components of lactose?
   a. glucose & galactose
   b. fructose and galactose
   c. glucose & fructose
   d. glucose and glucose

13. What type of chemical bond is illustrated by the arrows below?



   a. sugar-sugar bond
   b. glycerol- fatty acid bond
   c. peptide bond
   d. hydrogen bond

14. Which of the following sugars are the components of maltose?
   a. glucose & galactose
   b. fructose and galactose
   c. glucose & fructose
   d. glucose and glucose

15. The sugar in RNA is _____________, the sugar in DNA is ________.
   a. deoxyribose, ribose
   b. ribose, deoxyribose
   c. ribose, phosphate
   d. ribose, uracil

References and Links

Printed Materials:

Davis, Raymond E., Frey, Regina, Sarquis, Mickey, Sarquis Jerry L. (2009). *Modern Chemistry* (Teacher's edition) Holt, Rinehart and Winston, USA

LeMay, Jr. Eugene H., et al. (2000). *Chemistry Connections to Our Changing World* (Teacher's Edition) Prentice Hall, Inc. Upper Saddle River, NJ 07458

Chang, Raymond, (1998). *Chemistry*. 6th edition. Mc Graw-Hill Companies, Inc.

Comparison between DNA and RNA. Retreived from http://www.diffen.com/difference/ DNA vs RNA

Electronic Sources:

http://learningcenter.nsta.org/products/symposia_seminars/ACS/webseminar11.aspx

Images for chemical structure of glucose and fructose. Retrieved from http://www.nsta.org/publications/press/extras/morechemistry.

Images for the hydrolysis of sucrose. Retrieved from
http://www.mhhe.com/biosci/pae/botany/uno/graphics/uno01pob/vrl/images/0019.gif

Images for the chemical structures of starch and cellulose. Retrieved from
https://www.google.com.ph/search?q=chemical+structure+of+starch&client=firefox-a&hs=Qgc&rls=org.mozilla:

Images for the chemical structure of triglycerides. Retrieved from
https://www.google.com.ph/search?q=chemical+structure+of+triglycerides&client=firefox-a&rls=org.mozilla:en-US:official&channel=sb&source=lnms&tbm=isch&sa=X&ei=f6USU5XkFYyXkgWFp4DoBA&ved=0CAcQ_AUoAQ&biw=1207&bih=518

Image for hydrogenation reaction. Retreived from
http://www.chemguide.co.uk/organicprops/alkenes/hydrogenation.html

Pictures of food samples-Carbohydrates, Lipids, And Proteins. Retreived from
http://www.slideshare.net/gurustip/carbohydrathttp://edtech2.boisestate.edu/jonfreer/502/jigsaw.htmles-lipids-and-proteins-presentation

Identifying Biomolecules in Foods.Retreived from
http://www.cteonline.org/portal/default/Curriculum/Viewer/Curriculum?action=2&view=viewer&cmobjid=177679. March 6, 2014

Biomolecules Jigsaw Activity. Retreived from
http://edtech2.boiestate.edu/jonfreer/502/jigsaw.html. March 6,2014

http://joelbergerdc.com/tag/glucose-vs-fructose/

https://courses.ecampus.oregonstate.edu/ans312/one/carbs_story.htm

http://www.natuurlijkerwijs.com/english/Glycogen_metabolism.htm

https://myorganicchemistry.wikispaces.com/Cellulose?responseToken=1a9131f668de1a94603bbdfb79f69128

http://pixshark.com/phospholipid-bilayer-diagram.htm

http://en.wikipedia.org/wiki/Micelle

https://courses.ecampus.oregonstate.edu/ans312/one/lipids.htm

http://sphweb.bumc.bu.edu/otlt/MPH-Modules/PH/PH709_BasicCellBiology/PH709_BasicCellBiology24.html

http://entrytest-preparation.blogspot.com/2014/01/amino-acids.html

http://www.physicalgeography.net/fundamentals/10h.html