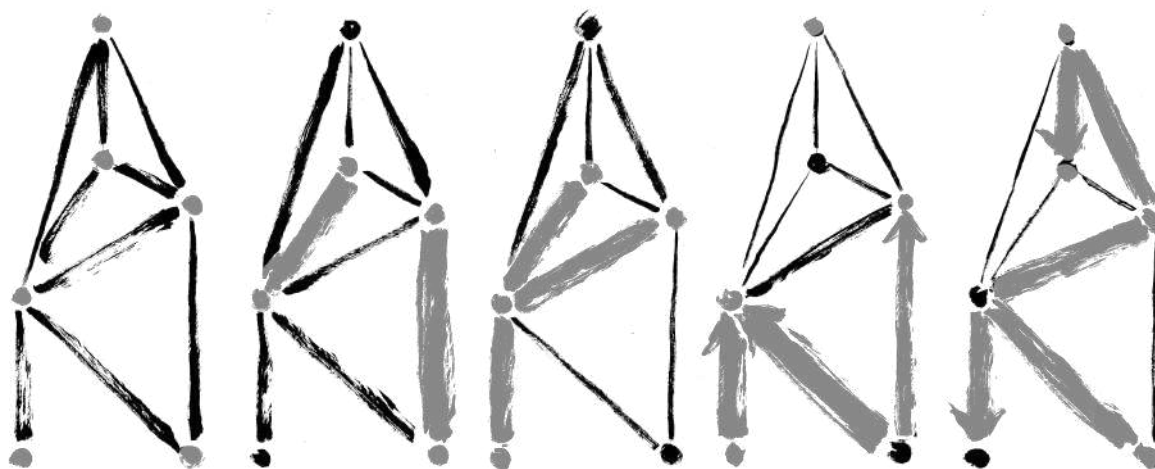


*The Commission on Higher Education
in collaboration with the Philippine Normal University*



Teaching Guide for Senior High School

EARTH AND LIFE SCIENCE

CORE SUBJECT

This Teaching Guide was collaboratively developed and reviewed by educators from public and private schools, colleges, and universities. We encourage teachers and other education stakeholders to email their feedback, comments, and recommendations to the Commission on Higher Education, K to 12 Transition Program Management Unit - Senior High School Support Team at k12@ched.gov.ph. We value your feedback and recommendations.



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Introduction

As the Commission supports DepEd's implementation of Senior High School (SHS), it upholds the vision and mission of the K to 12 program, stated in Section 2 of Republic Act 10533, or the Enhanced Basic Education Act of 2013, that "every graduate of basic education be an empowered individual, through a program rooted on...the competence to engage in work and be productive, the ability to coexist in fruitful harmony with local and global communities, the capability to engage in creative and critical thinking, and the capacity and willingness to transform others and oneself."

To accomplish this, the Commission partnered with the Philippine Normal University (PNU), the National Center for Teacher Education, to develop Teaching Guides for Courses of SHS. Together with PNU, this Teaching Guide was studied and reviewed by education and pedagogy experts, and was enhanced with appropriate methodologies and strategies.

Furthermore, the Commission believes that teachers are the most important partners in attaining this goal. Incorporated in this Teaching Guide is a framework that will guide them in creating lessons and assessment tools, support them in facilitating activities and questions, and assist them towards deeper content areas and competencies. Thus, the introduction of the **SHS for SHS Framework**.

SHS for SHS Framework

The SHS for SHS Framework, which stands for "Saysay-Husay-Sarili for Senior High School," is at the core of this book. The lessons, which combine high-quality content with flexible elements to accommodate diversity of teachers and environments, promote these three fundamental concepts:

SAYSAY: MEANING

Why is this important?

Through this Teaching Guide, teachers will be able to facilitate an understanding of the value of the lessons, for each learner to fully engage in the content on both the cognitive and affective levels.

HUSAY: MASTERY

How will I deeply understand this?

Given that developing mastery goes beyond memorization, teachers should also aim for deep understanding of the subject matter where they lead learners to analyze and synthesize knowledge.

SARILI: OWNERSHIP

What can I do with this?

When teachers empower learners to take ownership of their learning, they develop independence and self-direction, learning about both the subject matter and themselves.

About this Teaching Guide

Earth Science is a Core Subject taken in the first semester of Grade 11. This learning area is designed to provide a general background for the understanding of the Earth on a planetary scale. It presents the history of the Earth through geologic time. It discusses the Earth's structure and composition, the processes that occur beneath and on the Earth's surface, as well as issues, concerns, and problems pertaining to Earth's resources.

Implementing this course at the senior high school level is subject to numerous challenges with mastery of content among educators tapped to facilitate learning and a lack of resources to deliver the necessary content and develop skills and attitudes in the learners, being foremost among these.

In support of the SHS for SHS framework developed by CHED, these teaching guides were crafted and refined by biologists and biology educators in partnership with educators from focus groups all over the Philippines to provide opportunities to develop the following:

Saysay through meaningful, updated, and context-specific content that highlights important points and common misconceptions so that learners can connect to their real-world experiences and future careers;

Husay through diverse learning experiences that can be implemented in a resource-poor classroom or makeshift laboratory that tap cognitive, affective, and psychomotor domains are accompanied by field-tested teaching tips that aid in facilitating discovery and development of higher-order thinking skills; and

Sarili through flexible and relevant content and performance standards allow learners the freedom to innovate, make their own decisions, and initiate activities to fully develop their academic and personal potential.

These ready-to-use guides are helpful to educators new to either the content or biology new to the experience of teaching Senior High School due to their enriched content presented as lesson plans or guides. Veteran educators may also add ideas from these guides to their repertoire. The Biology Team hopes that this resource may aid in easing the transition of the different stakeholders into the new curriculum as we move towards the constant improvement of Philippine education.

Parts of the Teaching Guide

This Teaching Guide is mapped and aligned to the DepEd SHS Curriculum, designed to be highly usable for teachers. It contains classroom activities and pedagogical notes, and is integrated with innovative pedagogies. All of these elements are presented in the following parts:

1. Introduction

- Highlight key concepts and identify the essential questions
- Show the big picture
- Connect and/or review prerequisite knowledge
- Clearly communicate learning competencies and objectives
- Motivate through applications and connections to real-life

2. Motivation

- Give local examples and applications
- Engage in a game or movement activity
- Provide a hands-on/laboratory activity
- Connect to a real-life problem

3. Instruction/Delivery

- Give a demonstration/lecture/simulation/hands-on activity
- Show step-by-step solutions to sample problems
- Give applications of the theory
- Connect to a real-life problem if applicable

4. Practice

- Discuss worked-out examples
- Provide easy-medium-hard questions
- Give time for hands-on unguided classroom work and discovery
- Use formative assessment to give feedback

5. Enrichment

- Provide additional examples and applications
- Introduce extensions or generalisations of concepts
- Engage in reflection questions
- Encourage analysis through higher order thinking prompts

6. Evaluation

- Supply a diverse question bank for written work and exercises
- Provide alternative formats for student work: written homework, journal, portfolio, group/individual projects, student-directed research project

On DepEd Functional Skills and CHED College Readiness Standards

As Higher Education Institutions (HEIs) welcome the graduates of the Senior High School program, it is of paramount importance to align Functional Skills set by DepEd with the College Readiness Standards stated by CHED.

The DepEd articulated a set of 21st century skills that should be embedded in the SHS curriculum across various subjects and tracks. These skills are desired outcomes that K to 12 graduates should possess in order to proceed to either higher education, employment, entrepreneurship, or middle-level skills development.

On the other hand, the Commission declared the College Readiness Standards that consist of the combination of knowledge, skills, and reflective thinking necessary to participate and succeed - without remediation - in entry-level undergraduate courses in college.

The alignment of both standards, shown below, is also presented in this Teaching Guide - prepares Senior High School graduates to the revised college curriculum which will initially be implemented by AY 2018-2019.

College Readiness Standards Foundational Skills	DepEd Functional Skills
Produce all forms of texts (written, oral, visual, digital) based on: 1. Solid grounding on Philippine experience and culture; 2. An understanding of the self, community, and nation; 3. Application of critical and creative thinking and doing processes; 4. Competency in formulating ideas/arguments logically, scientifically, and creatively; and 5. Clear appreciation of one's responsibility as a citizen of a multicultural Philippines and a diverse world;	Visual and information literacies, media literacy, critical thinking and problem solving skills, creativity, initiative and self-direction
Systematically apply knowledge, understanding, theory, and skills for the development of the self, local, and global communities using prior learning, inquiry, and experimentation	Global awareness, scientific and economic literacy, curiosity, critical thinking and problem solving skills, risk taking, flexibility and adaptability, initiative and self-direction
Work comfortably with relevant technologies and develop adaptations and innovations for significant use in local and global communities	Global awareness, media literacy, technological literacy, creativity, flexibility and adaptability, productivity and accountability
Communicate with local and global communities with proficiency, orally, in writing, and through new technologies of communication	Global awareness, multicultural literacy, collaboration and interpersonal skills, social and cross-cultural skills, leadership and responsibility
Interact meaningfully in a social setting and contribute to the fulfilment of individual and shared goals, respecting the fundamental humanity of all persons and the diversity of groups and communities	Media literacy, multicultural literacy, global awareness, collaboration and interpersonal skills, social and cross-cultural skills, leadership and responsibility, ethical, moral, and spiritual values

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**K to 12 BASIC EDUCATION CURRICULUM
SENIOR HIGH SCHOOL – CORE SUBJECT**

Grade: 11/12

Core Subject Title: Earth and Life Science

Academic Year: 1

No. of Hours: 80 hours (20 Weeks)

Pre-requisite (if needed):

Core Subject Description: This learning area is designed to provide a general background for the understanding of Earth Science and Biology. It presents the history of the Earth through geologic time. It discusses the Earth's structure, composition, and processes. Issues, concerns, and problems pertaining to natural hazards are also included. It also deals with the basic principles and processes in the study of biology. It covers life processes and interactions at the cellular, organism, population, and ecosystem levels.

GRADE 11 FIRST QUARTER				
CONTENT	CONTENT STANDARD	PERFORMANCE STANDARD	LEARNING COMPETENCIES	CODE
I. ORIGIN AND STRUCTURE OF THE EARTH A. Universe and Solar System B. Earth and Earth Systems	<i>The learners demonstrate an understanding of:</i> 1. the formation of the universe and the solar system 2. the subsystems (geosphere, hydrosphere, atmosphere, and biosphere) that make up the Earth 3. the Earth's internal structure	<i>The learners shall be able to:</i> 1. Conduct a survey to assess the possible geologic hazards that your community may experience. <i>(Note: Select this performance standard if your school is in an area near faultlines, volcanoes, and steep slopes.)</i> 2. Conduct a survey or design a study to assess the possible hydrometeorological hazards that your community may	<i>The learners:</i> 1. State the different hypotheses explaining the origin of the universe.	S11/12ES-Ia-e-1
			2. Describe the different hypotheses explaining the origin of the solar system.	S11/12ES-Ia-e-2
			3. Recognize the uniqueness of Earth, being the only planet in the solar system with properties necessary to support life.	S11/12ES-Ia-e-3
			4. Explain that the Earth consists of four subsystems, across whose boundaries matter and energy flow.	S11/12ES-Ia-e-4
			5. Explain the current advancements/information on the solar system	S11/12ES-Ia-e-5
			6. Show the contributions of personalities/people on the	S11/12ES-Ia-e-6

**K to 12 BASIC EDUCATION CURRICULUM
SENIOR HIGH SCHOOL – CORE SUBJECT**

CONTENT	CONTENT STANDARD	PERFORMANCE STANDARD	LEARNING COMPETENCIES	CODE	
		experience. (<i>Note: Select this performance standard if your school is in an area that is frequently hit by tropical cyclones and is usually flooded.</i>)	understanding of the earth systems		
			7. Identify the layers of the Earth (crust, mantle, core).	S11/12ES-Ia-e-7	
			8. Differentiate the layers of the Earth.	S11/12ES-Ia-e-8	
II. EARTH MATERIALS AND PROCESSES A. Minerals and Rocks	<i>The learners demonstrate an understanding of:</i> 1. the three main categories of rocks		<i>The learners:</i> 1. identify common rock-forming minerals using their physical and chemical properties 2. classify rocks into igneous, sedimentary, and metamorphic	S11/12ES-Ia-9	
	2. the origin and environment of formation of common minerals and rocks			S11/12ES-Ib-10	
	B. Exogenic Processes		3. geologic processes that occur on the surface of the Earth such as weathering, erosion, mass wasting, and sedimentation (include the role of ocean basins in the formation of sedimentary rocks)	3. describe how rocks undergo weathering	S11/12ES-Ib-11
				4. explain how the products of weathering are carried away by erosion and deposited elsewhere	S11/12ES-Ib-12
				5. make a report on how rocks and soil move downslope due to the direct action of gravity	S11/12ES-Ib-13
	C. Endogenic Processes		4. geologic processes that occur within the Earth	6. describe where the Earth’s internal heat comes from.	S11/12ES-Ib-14
				7. describe how magma is formed (magmatism)	S11/12ES-Ic-15
			5. the folding and faulting of rocks	8. describe what happens after the magma is formed (plutonism and volcanism)	S11/12ES-Ic-16
				9. describe the changes in mineral components and texture of rocks due to changes in pressure and temperature (metamorphism)	S11/12ES-Ic-17

**K to 12 BASIC EDUCATION CURRICULUM
SENIOR HIGH SCHOOL – CORE SUBJECT**

CONTENT	CONTENT STANDARD	PERFORMANCE STANDARD	LEARNING COMPETENCIES	CODE
			10. compare and contrast the formation of the different types of igneous rocks	S11/12ES-Ic-18
			11. describe how rocks behave under different types of stress such as compression, pulling apart, and shearing	S11/12ES-Ic-19
D. Deformation of the Crust	6. plate tectonics		12. explain how the continents drift	S11/12ES-Id-20
	13. cite evidence that support continental drift		S11/12ES-Id-21	
	14. explain how the movement of plates leads to the formation of folds and faults		S11/12ES-Id-22	
	15. explain how the seafloor spreads		S11/12ES-Id-23	
	16. describe the structure and evolution of ocean basins		S11/12ES-Id-24	
E. History of the Earth	7. how the planet Earth evolved in the last 4.6 billion years (including the age of the Earth, major geologic time subdivisions, and marker fossils).		17. describe how layers of rocks (stratified rocks) are formed	S11/12ES-Ie-25
			18. describe the different methods (relative and absolute dating) to determine the age of stratified rocks	S11/12ES-Ie-26
			19. explain how relative and absolute dating were used to determine the subdivisions of geologic time	S11/12ES-Ie-27
			20. describe how marker fossils (also known as guide fossils) are used to define and identify subdivisions of the geologic time scale	S11/12ES-Ie-28

**K to 12 BASIC EDUCATION CURRICULUM
SENIOR HIGH SCHOOL – CORE SUBJECT**

CONTENT	CONTENT STANDARD	PERFORMANCE STANDARD	LEARNING COMPETENCIES	CODE
			21. describe how the Earth's history can be interpreted from the geologic time scale	S11/12ES-Ie-29
III. NATURAL HAZARDS, MITIGATION, AND ADAPTATION	<i>The learners demonstrate an understanding of:</i>		<i>The learners:</i>	
A. Geologic Processes and Hazards	1. the different hazards caused by geological processes (earthquakes, volcanic eruptions, and landslides)		1. describe the various hazards that may happen in the event of earthquakes, volcanic eruptions, and landslides	S11/12ES-If-30
B. Hydrometeorological Phenomena and Hazards	2. the different hazards caused by hydrometeorological phenomena (tropical cyclones, monsoons, floods, and tornadoes or <i>ipo-ipo</i>)		3. using hazard maps, identify areas prone to hazards brought about by earthquakes, volcanic eruptions, and landslides	S11/12ES-If-31
			4. give practical ways of coping with geological hazards caused by earthquakes, volcanic eruptions, and landslides	S11/12ES-If-32
			5. identify human activities that speed up or trigger landslides	S11/12ES-If-33
			6. suggest ways to help lessen the occurrence of landslides in your community	S11/12ES-Ig-34
C. Marine and Coastal Processes and their Effects	3. the different hazards caused by coastal processes (waves, tides, sea-level changes, crustal movement, and storm surges)		7. describe the various hazards that may happen in the wake of tropical cyclones, monsoons, floods, or ipo-ipo	S11/12ES-Ig-35
			8. using hazard maps, identify areas prone to hazards brought about by tropical cyclones, monsoons, floods, or ipo-ipo	S11/12ES-Ig-36

**K to 12 BASIC EDUCATION CURRICULUM
SENIOR HIGH SCHOOL – CORE SUBJECT**

CONTENT	CONTENT STANDARD	PERFORMANCE STANDARD	LEARNING COMPETENCIES	CODE
			9. give practical ways of coping with hydrometeorological hazards caused by tropical cyclones, monsoons, floods, or ipo-ipo	S11/12ES-Ih-37
			10. describe how coastal processes result in coastal erosion, submersion, and saltwater intrusion	S11/12ES-Ih-38
			11. identify areas in your community prone to coastal erosion, submersion, and saltwater intrusion	S11/12ES-Ii-39
			12. give practical ways of coping with coastal erosion, submersion, and saltwater intrusion	S11/12ES-Ii-40
			13. cite ways to prevent or mitigate the impact of land development, waste disposal, and construction of structures on control coastal processes	S11/12ES-Ii-41

**K to 12 BASIC EDUCATION CURRICULUM
SENIOR HIGH SCHOOL – CORE SUBJECT**

CONTENT	CONTENT STANDARD	PERFORMANCE STANDARD	LEARNING COMPETENCIES	CODE
I. INTRODUCTION TO LIFE SCIENCE	<i>The learners demonstrate an understanding of:</i> - the historical development of the concept of life - the origin of the first life forms - unifying themes in the study of life	<i>The learners shall be able to:</i> value life by taking good care of all beings, humans, plants, and animals	<i>The learners:</i> explain the evolving concept of life based on emerging pieces of evidence	S11/12LT-IIa-1
			describe classic experiments that model conditions which may have enabled the first forms to evolve	S11/12LT-IIa-2
			describe how unifying themes (e.g., structure and function, evolution, and ecosystems) in the study of life show the connections among living things and how they interact with each other and with their environment	S11/12LT-IIa-3
II. BIOENERGETICS	<i>The learners demonstrate an understanding of:</i> - the cell as the basic unit of life - how photosynthetic organisms capture light energy to form sugar molecules - how organisms obtain and utilize energy	<i>The learners shall be able to:</i> make a poster that shows the complementary relationship of photosynthesis and cellular respiration	<i>The learners:</i> explain how cells carry out functions required for life	S11/12LT-IIbd-4
			explain how photosynthetic organisms use light energy to combine carbon dioxide and water to form energy-rich compounds	S11/12LT-IIbd-5
			trace the energy flow from the environment to the cells.	S11/12LT-IIbd-6
			describe how organisms obtain and utilize energy	S11/12LT-IIbd-7
			recognize that organisms require energy to carry out functions required for life	S11/12LT-IIbd-8

**K to 12 BASIC EDUCATION CURRICULUM
SENIOR HIGH SCHOOL – CORE SUBJECT**

CONTENT	CONTENT STANDARD	PERFORMANCE STANDARD	LEARNING COMPETENCIES	CODE
III. PERPETUATION OF LIFE	<i>The learners demonstrate an understanding of:</i> 1. plant and animal reproduction	<i>The learners shall be able to:</i> conduct a survey of products containing substances that can trigger genetic disorders such as phenylketonuria	<i>The learners:</i> 1. describe the different ways of how plants reproduce	S11/12LT-IIej-13
			2. illustrate the relationships among structures of flowers, fruits, and seeds	S11/12LT-IIej-14
			3. describe the different ways of how representative animals reproduce	S11/12LT-IIej-15
	2. how genes work		4. explain how the information in the DNA allows the transfer of genetic information and synthesis of proteins	S11/12LT-IIej-16
	3. how genetic engineering is used to produce novel products		5. describe the process of genetic engineering	S11/12LT-IIej-17
			6. conduct a survey of the current uses of genetically modified organisms	S11/12LT-IIej-18
			7. evaluate the benefits and risks of using GMOs	S11/12LT-IIej-19
IV. HOW ANIMALS SURVIVE	<i>The learners demonstrate an understanding of:</i> 1. nutrition: getting food to cells 2. gas exchange with the environment	<i>The learners shall be able to:</i> make a presentation of some diseases that are associated with the various organ systems	<i>The learners:</i> 8. explain the different metabolic processes involved in the various organ systems	S11/12LT-IIIaj-20

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CONTENT	CONTENT STANDARD	PERFORMANCE STANDARD	LEARNING COMPETENCIES	CODE
	3. circulation: the internal transport system 4. the need for homeostasis 5. salt and water balance and waste removal 6. the immune system: defense from disease 7. how hormones govern body activities 8. the nervous system 9. the body in motion		9. describe the general and unique characteristics of the different organ systems in representative animals	S11/12LT-IIIaj-21
			10. analyze and appreciate the functional relationships of the different organ systems in ensuring animal survival	S11/12LT-IIIaj-22
V. HOW PLANTS SURVIVE	<i>The learners demonstrate an understanding of:</i> 1. plant form and function 2. plant growth and development	<i>The learners shall be able to:</i> design a setup on propagating plants using other methods such as hydroponics and aeroponics	<i>The learners:</i> 11. describe the structure and function of the different plant organs	S11/12LT-IVae-23
			12. explain the different metabolic processes involved in the plant organ systems	S11/12LT-IVae-24

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CONTENT	CONTENT STANDARD	PERFORMANCE STANDARD	LEARNING COMPETENCIES	CODE
VI. THE PROCESS OF EVOLUTION	<i>The learners demonstrate an understanding of:</i> - the evidence for evolution - the origin and extinction of species	<i>The learners shall be able to:</i> Design a poster tracing the evolutionary changes in a crop plant (e.g., rice or corn) that occurred through domestication	<i>The learners:</i> 13. describe evidence of evolution such as homology, DNA/protein sequences, plate tectonics, fossil record, embryology, and artificial selection/agriculture	S11/12LT-IVfg-25
			13. explain how populations of organisms have changed and continue to change over time showing patterns of descent with modification from common ancestors to produce the organismal diversity observed today	S11/12LT-IVfg-26
			14. describe how the present system of classification of organisms is based on evolutionary relationships	S11/12LT-IVfg-27
VII. INTERACTION AND INTERDEPENDENCE	<i>The learners demonstrate an understanding of:</i> - the principles of the ecosystem - biotic potential and environmental resistance - terrestrial and aquatic ecosystems	<i>The learners shall be able to:</i> prepare an action plan containing mitigation measures to address current environmental concerns and challenges in the community	<i>The learners:</i> 15. describe the principles of the ecosystem	S11/12LT-IVhj-28
			16. categorize the different biotic potential and environmental resistance (e.g., diseases, availability of food, and predators) that affect population explosion	S11/12LT-IVhj-29

**K to 12 BASIC EDUCATION CURRICULUM
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CONTENT	CONTENT STANDARD	PERFORMANCE STANDARD	LEARNING COMPETENCIES	CODE
	4. how human activities affect the natural ecosystem		17. describe how the different terrestrial and aquatic ecosystems are interlinked with one another	S11/12LT-IVhj-30

GLOSSARY

Absolute Dating

The process of determining an approximate computed age in archaeology and geology

**K to 12 BASIC EDUCATION CURRICULUM
SENIOR HIGH SCHOOL – CORE SUBJECT**

GLOSSARY

Artificial Selection	The process in the breeding of animals and in the cultivation of plants by which the breeder chooses to perpetuate only those forms having certain desirable traits or characteristics
Bioenergetics	Energy transformations and energy exchanges within and between living things and their environments
Calvin Cycle	The term for the cycle of dark reactions in photosynthesis
Embryology	The study of organisms at their early stages of development
Endogenic	Refers to internal processes and phenomena that occur beneath the Earth's surface, or any other celestial body's
Genetic Engineering	The deliberate and controlled manipulation of genes in an organism, with the intent of making that organism better in some way
Genetically Modified Organism	An organism whose genetic material has been altered using genetic engineering techniques. Organisms that have been genetically modified include micro-organisms such as bacteria and yeast, insects, plants, fish, and mammals
Geologic Process	A natural process whereby geological features are modified
Homology	The study of likeness in structure between parts of different organisms (e.g., the wing of a bat and the human arm) due to evolutionary differentiation from a corresponding part in a common ancestor
Hydrometeorological Hazards	The process or phenomenon of atmospheric, hydrological, or oceanographic nature that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage
Metamorphism	The process of dramatic changes in body form in the life cycle of some animals
Physiology	The study of the functions of living things and their parts
Plate Tectonics	The branch of geology that studies the folding and faulting of the Earth's crust
Plutonism	The formation of intrusive igneous rocks by solidification of magma beneath the earth's surface
Relative Dating	A technique used to determine the age of fossils by comparing them with other fossils in different layers of rock

Code Book Legend

Lesson 1: Universe and the Solar System

Content Standard

The learners demonstrate an understanding of the formation of the universe.

Learning Competency

The learners shall be able to state the different hypotheses and theories explaining the origin of the universe **(S11/12ES-la-e-1)**.

Specific Learning Outcomes

At the end of this lesson, the learners will be able to:

1. Describe the structure and composition of the Universe;
2. State the different hypothesis that preceded the Big Bang Theory of the Origin of the Universe.
3. Explain the red-shift and how it used as proof of an expanding universe; and
4. Explain the Big Bang Theory and evidences supporting the theory.

LESSON OUTLINE

Introduction	Presentation of Objectives and Terms	10
Motivation	How big is a billion?	10
Instruction	Lecture Proper and Discussion	30
Enrichment	Will the Universe continue to Expand?	
Evaluation	Report	10

Materials

Projector or Print-out of Figures

Resources

- (1) http://imagine.gsfc.nasa.gov/educators/lesson_plans.html
- (2) <http://imagine.gsfc.nasa.gov/educators/materials.html>
- (3) <http://www.astro.princeton.edu/~dns/teachersguide/website.pdf>
- (4) http://map.gsfc.nasa.gov/universe/WMAP_Universe.pdf (accessed 3 October 2015)
- (5) <https://en.wikipedia.org/wiki/Universe> (accessed 4 October 2015)
- (6) <https://www.youtube.com/watch?v=RPVvgJoddO4&list=PLrhG2NtyHAZuPW5HP3cyenGGTUqUhumeQ> (accessed 25 October 2015)
- (7) Steinhardt P and N Turok. Endless Universe, <http://www.physics.princeton.edu/~steinh/endlessuniverse/askauthors.html> (accessed 13 October 2015)

Additional Resources at the End of this Lesson

INTRODUCTION (10 MINS)

1. Introduce the following learning objectives and important terms
 - A. Describe the structure and composition of the Universe;
 - B. Explain the red-shift and how it used as proof of an expanding universe
 - C. State the different hypothesis that preceded the Big Bang Theory of the Origin of the Universe
 - D. Explain the Big Bang Theory

2. Introduce the list of important terms that learners will encounter.
 - A. **Baryonic matter** - "ordinary" matter consisting of protons, electrons, and neutrons that comprises atoms, planets, stars, galaxies, and other bodies
 - B. **Dark matter** - matter that has gravity but does not emit light.
 - C. **Dark Energy** - a source of anti-gravity; a force that counteracts gravity and causes the universe to expand.
 - D. **Protostar** - an early stage in the formation of a star resulting from the gravitational collapse of gases.
 - E. **Thermonuclear reaction** - a nuclear fusion reaction responsible for the energy produced by stars.
 - F. **Main Sequence Stars** - stars that fuse hydrogen atoms to form helium atoms in their cores; outward pressure resulting from nuclear fusion is balanced by gravitational forces
 - G. **Light years** - the distance light can travel in a year; a unit of length used to measure astronomical distance

Teacher Tip:

Alternatively, these terms can be defined during the instruction/delivery.

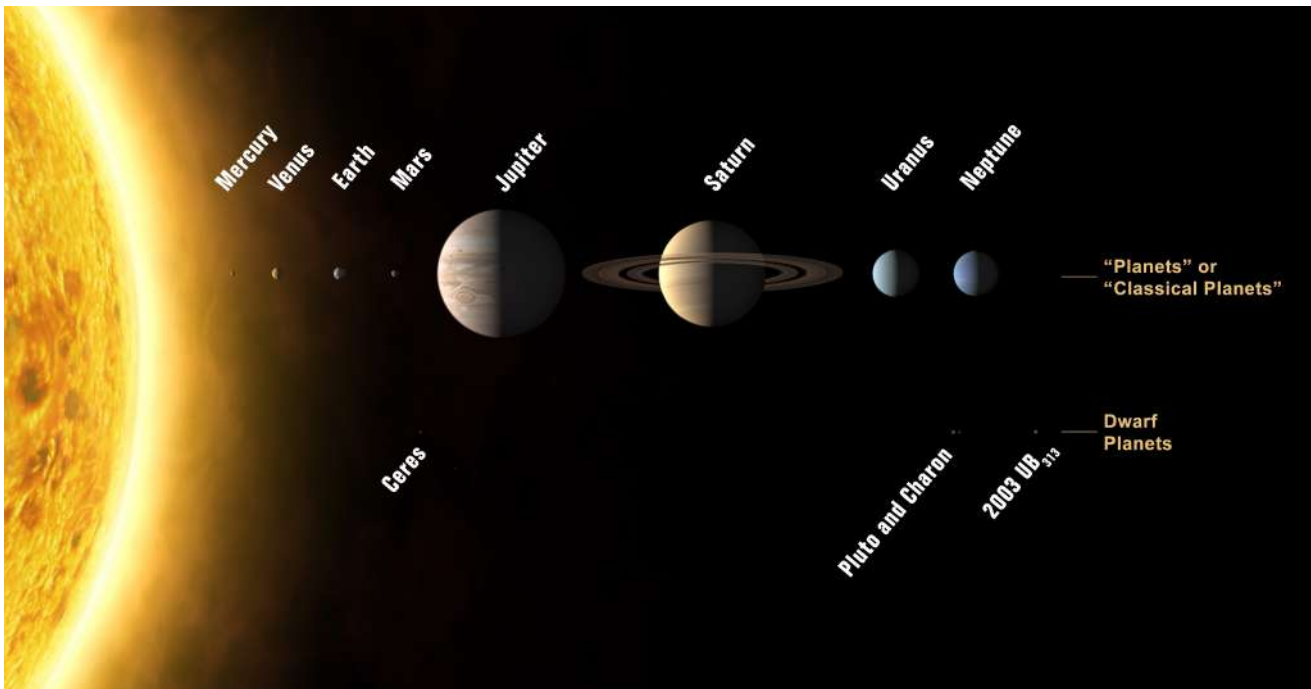
MOTIVATION (10 MINS)

Connect the lesson to a real-life problem or question.

1. Tell the learners that the Universe is at least 13.8 billion of years old and the Earth/Solar System at least 4.5-4.6 billions of years old. But how large exactly is a billion? Ask the learners how long will it take them to spend 1 billion pesos if they spend 1 peso per second.

- A. $1 \text{ billion} / (60 \text{ s/min} \times 60 \text{ min/hr} \times 24 \text{ hr/day} \times 365 \text{ days/year})$
- B. ~32 years
- C. How long is 13.8 billion years?

2. Show learners the series of photographs as follows:



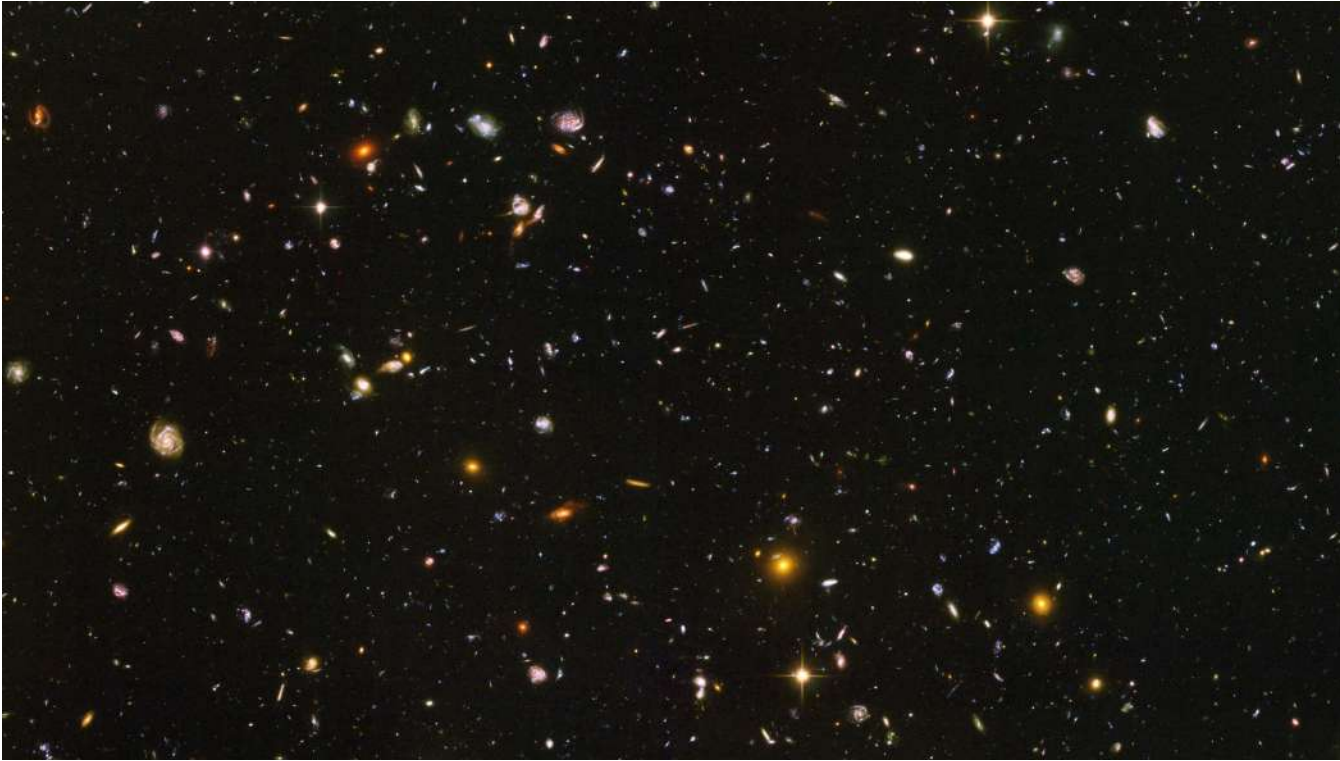
Source: The Solar System ([https://upload.wikimedia.org/wikipedia/commons/d/d9/Solar_System_\(annotated\).jpg](https://upload.wikimedia.org/wikipedia/commons/d/d9/Solar_System_(annotated).jpg))

Teacher Tip

- The purpose of the activity is to emphasize the immensity of time and by extension (relationship between space and time) the vastness of space (universe).
- Alternatively, you may also ask learners what they know about the universe.

Situate the Earth (and by extension themselves) with respect to the Universe

- The Earth as part of the solar system - inner terrestrial (as opposed to the outer gaseous planets) . Earth is also known as "the third rock from the Sun".
- The solar system as part of the Milky Way Galaxy. Note the Sun (solar system) is at the outer limb of the galaxy (not at the center!)



Source: The Hubble Deep Field (<https://www.google.com.ph/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=0ahUKEwjOuKaQlaTNAhXCqJQKHStrA5kQjBwIbA&url=http%3A%2F%2Fwallpapercave.com%2Fwp%2FTlqblsL.jpg&psig=AFQjCNFfHuF9reOYsnpNluRLoYAVcVeObA&ust=1465878504806484>)

Teacher Tip:

- The Milky Way is but one of the billions of Galaxies in the Universe.
- We are definitely not at the center of the universe.
- Post the question to the learners and solicit their opinion:
- Is there a center?

You may check the following link to help in the discussion.

<http://math.ucr.edu/home/baez/physics/Relativity/GR/centre.html>

INSTRUCTION (30 MINS)

Give a demonstration/lecture/simulation

Introduction:

Any explanation of the origin of the Universe should be consistent with all information about its **composition, structure, accelerating expansion, cosmic microwave background radiation** among others.

Structure, Composition, and Age

- The universe as we currently know it comprises all space and time, and all matter and energy in it.
- It is made of **4.6% baryonic matter** ("ordinary" matter consisting of protons, electrons, and neutrons: atoms, planets, stars, galaxies, nebulae, and other bodies), **24% cold dark matter** (matter that has gravity but does not emit light), and **71.4% dark energy** (a source of anti-gravity)
- Dark matter can explain what may be holding galaxies together for the reason that the low total mass is insufficient for gravity alone to do so while dark energy can explain the observed accelerating expansion of the universe.
- **Hydrogen, helium, and lithium** are the three most abundant elements.
- **Stars** - the building block of galaxies-are born out of clouds of gas and dust in galaxies. Instabilities within the clouds eventually results into gravitational collapse, rotation, heating up, and transformation into a **protostar**-the hot core of a future star as **thermonuclear reactions** set in.
- Stellar interiors are like furnaces where elements are synthesized or combined/fused together. Most stars such as the Sun belong to the so-called "**main sequence stars**." In the cores of such stars, hydrogen atoms are fused through **thermonuclear reactions** to make helium atoms. Massive main sequence stars burn up their hydrogen faster than smaller stars. Stars like our Sun burnup hydrogen in about 10 billion years.

Teacher Tip:

Hydrogen and Helium as the most abundant elements in the universe. Having the lowest mass, these are the first elements to be formed in the Big Bang Model of the Origin of the Universe.

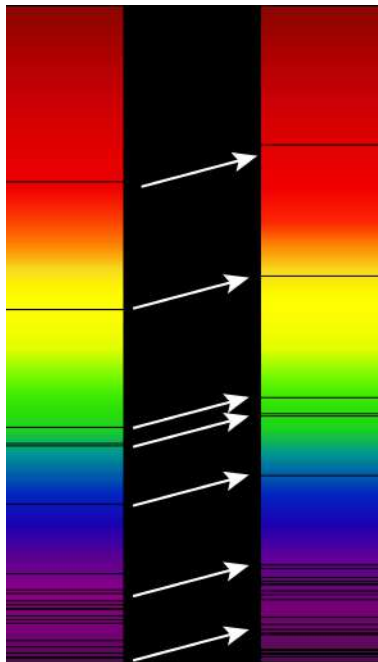
- A star's energy comes from combining light elements into heavier elements by fusion, or "nuclear burning" (nucleosynthesis). In small stars like the sun, H burning is the fusion of 4 H nuclei (protons) into a He nucleus (2 protons + 2 neutrons).
- Forming He from H gives off lots of energy(i.e. a natural hydrogen bomb).
- Nucleosynthesis requires very high T. The minimum T for H fusion is 5×10^6 °C.

Birth, evolution, death, and rebirth of stars

- The remaining dust and gas may end up as they are or as planets, asteroids, or other bodies in the accompanying planetary system.
- A **galaxy** is a cluster of billions of stars and clusters of galaxies form superclusters. In between the clusters is practically an empty space. This organization of matter in the universe suggests that it is indeed clumpy at a certain scale. But at a large scale, it appears homogeneous and isotropic.
- Based on recent data, the universe is **13.8 billion years old**. The diameter of the universe is possibly infinite but should be at least 91 billion light-years ($1 \text{ light-year} = 9.4607 \times 10^{12} \text{ km}$). Its density is $4.5 \times 10^{-31} \text{ g/cm}^3$.

Expanding Universe

- In 1929, Edwin Hubble announced his significant discovery of the **"redshift"** and its interpretation that galaxies are moving away from each other, hence as evidence for an expanding universe, just as predicted by Einstein's **Theory of General Relativity**.
- He observed that spectral lines of starlight made to pass through a prism are shifted toward the red part of the electromagnetic **spectrum**, i.e., toward the band of lower frequency; thus, the inference that the star or galaxy must be moving away from us.



Red shift as evidence for an expanding universe. The positions of the absorptions lines for helium for light coming from the Sun are shifted towards the red end as compared with those for a distant star. This evidence for expansion contradicted the previously held view of a static and unchanging universe.

Source: The Red Shift (<https://www.google.com.ph/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=0ahUKEwjZwbe9mKTNAhWCUZQKHYNFAzMQjBwIBA&url=https%3A%2F%2Fupload.wikimedia.org%2Fwikipedia%2Fcommons%2Fthumb%2F6%2F6a%2FRedshift.svg%2F2000px-Redshift.svg.png&psig=AFQjCNEp2yshF0mgavwc8uQljiNouS9RyA&ust=1465879400062773>)

<https://www.google.com.ph/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=0ahUKEwjZwbe9mKTNAhWCUZQKHYNFAzMQjBwIBA&url=https%3A%2F%2Fupload.wikimedia.org%2Fwikipedia%2Fcommons%2Fthumb%2F6%2F6a%2FRedshift.svg%2F2000px-Redshift.svg.png&psig=AFQjCNEp2yshF0mgavwc8uQljiNouS9RyA&ust=1465879400062773>

Teacher Tip:

- This is similar to the **Doppler effect** for sound waves: to a stationary observer, the frequency or pitch of a receding source decreases as it moves away.

Activity : Doppler Effect and Interactive

Source: <http://molebash.com/doppler/horn/horn1.ht>

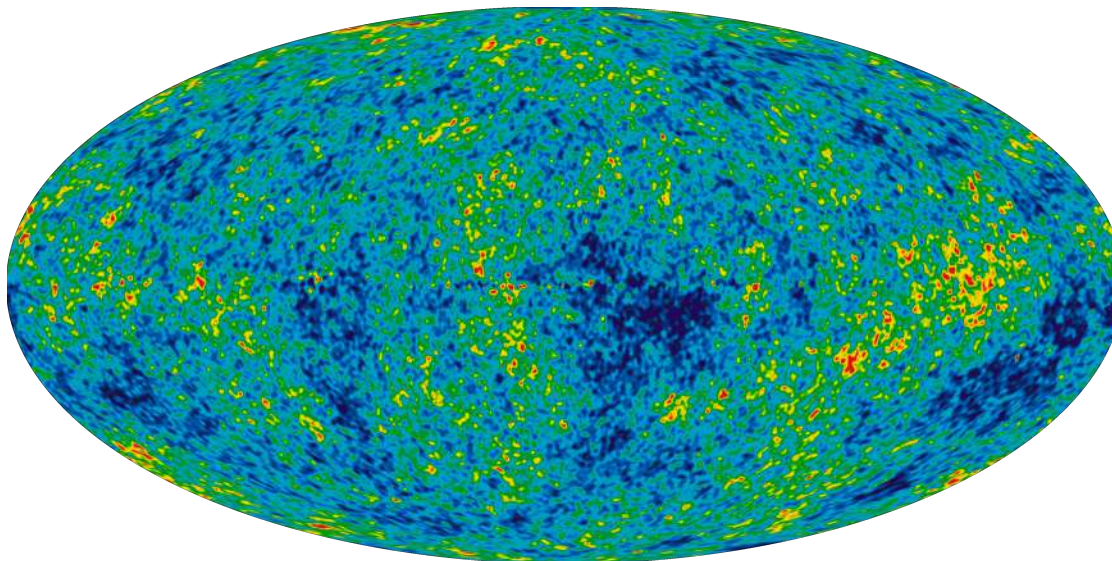
1. Ask the learners to watch two short video clips filmed inside a car. Try to determine where the horn is coming from. Is it coming from inside the car or outside the car? If outside the car, where?
 - Video 1 - horn is coming from the inside of the car. There is hardly any change in the volume and pitch of the horn.
 - Video 2 - horn is coming from outside of the car. Specifically, the horn is coming from another car travelling in an opposite direction. Notice how the pitch and volume of the car varies with distance from the other car. Pitch and volume increases as the other car approaches.

Teacher Tip:

- If there is internet access, you can play these two movie clips directly from the website; (<http://molebash.com/doppler/horn/horn1.htm>)

Cosmic Microwave Background

1. There is a pervasive cosmic microwave background (CMB) radiation in the universe. Its accidental discovery in 1964 by Arno Penzias and Robert Woodrow Wilson earned them the physics Nobel Prize in 1978.
2. It can be observed as a strikingly uniform faint glow in the microwave band coming from all directions-blackbody radiation with an average temperature of about 2.7 degrees above absolute zero.



Source: Cosmic microwave background radiation map showing small variations from WMAP - (Wilkinson Microwave Anisotropy Probe)

(https://www.google.com.ph/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=0ahUKEwi-ia2AmqTNAhUHI5QKHcOjBjoQjBwIbA&url=https%3A%2F%2Fupload.wikimedia.org%2Fwikipedia%2Fcommons%2F3%2F3c%2FIlc_9yr_moll4096.png&bvm=bv.124272578,d.dGo&psig=AFQjCNFKLayV4rTg0JLSNVx2R6LonF7X_w&ust=1465879811382467)

Origin of the Universe

Non-scientific Thought

- Ancient Egyptians believed in many gods and myths which narrate that the world arose from an infinite sea at the first rising of the sun.
- The Kuba people of Central Africa tell the story of a creator god Mbombo (or Bumba) who, alone in a dark and water-covered Earth, felt an intense stomach pain and then vomited the stars, sun, and moon.
- In India, there is the narrative that gods sacrificed Purusha, the primal man whose head, feet, eyes, and mind became the sky, earth, sun, and moon respectively.
- The monotheistic religions of Judaism, Christianity, and Islam claim that a supreme being created the universe, including man and other living organisms.

Steady State Model

- The now discredited steady state model of the universe was proposed in 1948 by Bondi and Gould and by Hoyle.
- It maintains that new matter is created as the universe expands thereby maintaining its density.
- Its predictions led to tests and its eventual rejection with the discovery of the cosmic microwave background.

Big Bang Theory

- As the currently accepted theory of the origin and evolution of the universe, the Big Bang Theory postulates that 13.8 billion years ago, the universe expanded from a tiny, dense and hot mass to its present size and much cooler state.
- The theory rests on two ideas: General Relativity and the Cosmological Principle. In Einstein's General Theory of Relativity, gravity is thought of as a distortion of space-time and no longer described by a gravitational field in contrast to the Law of Gravity of Isaac Newton. General Relativity explains the peculiarities of the orbit of Mercury and the bending of light by the Sun and has passed rigorous tests. The Cosmological Principle assumes that the universe is homogeneous and isotropic when averaged over large scales. This is consistent with our current large-scale image of the universe. But keep in mind that it is clumpy at smaller scales.

Teacher Tip:

Unlike hypotheses in the sciences, religious beliefs cannot be subjected to tests using the scientific method. For this reason, they cannot be considered valid topic of scientific inquiry.

Teacher Tip:

The uniform nature (even in all direction) of the CMB precludes propagation from a point source (i.e. from ancient stars as explained by the steady state model).

Misconception:

The "bang" should not be taken as an explosion; it is better thought of a simultaneous appearance of space everywhere. The theory does not identify the cause of the "bang."

- The Big Bang Theory has withstood the tests for expansion: 1) the redshift 2) abundance of hydrogen, helium, and lithium, and 3) the uniformly pervasive cosmic microwave background radiation-the remnant heat from the bang.

Evolution of the Universe according to the Big Bang Theory

- From time zero (13.8 billion years ago) until 10^{-43} second later, all matter and energy in the universe existed as a hot, dense, tiny state. It then underwent extremely rapid, exponential inflation until 10^{-32} second later after which and until 10 seconds from time zero, conditions allowed the existence of only quarks, hadrons, and leptons.
- Then, Big Bang nucleosynthesis took place and produced protons, neutrons, atomic nuclei, and then hydrogen, helium, and lithium until 20 minutes after time zero when sufficient cooling did not allow further nucleosynthesis.
- From then on until 380,000 years, the cooling universe entered a matter-dominated period when photons decoupled from matter and light could travel freely as still observed today in the form of cosmic microwave background radiation.
- As the universe continued to cool down, matter collected into clouds giving rise to only stars after 380,000 years and eventually galaxies would form after 100 million years from time zero during which, through nucleosynthesis in stars, carbon and elements heavier than carbon were produced.
- From 9.8 billion years until the present, the universe became dark-energy dominated and underwent accelerating expansion. At about 9.8 billion years after the big bang, the solar system was formed.

Teacher Tip:

- It was previously thought that the gravity would eventually stop the expansion and end the universe with a "Big Crunch" and perhaps to generate another "bang" . This would occur if the density of the universe is greater than the critical density. But if it is lower, there would be not enough gravitational force to stop or reverse the expansion---the universe would expand forever leading to the "Big Chill" or "Big Freeze" since it cools during expansion. The recent observation of accelerating expansion suggests that the universe will expand exponentially forever.
- Submitted work may be evaluated using the following criteria:
- Logical discussion of scientific concepts used for the argument (e.g. effects of gravity, expansion), consistent discussions of pros and cons
- Logical build up of reasoning to support the choice.

ENRICHMENT (ASSIGNMENT)

1. Ask the learners to submit a brief report on the following topic/questions.

What is the fate of the universe? Will the universe continue to expand or will it eventually contract because of gravity?

EVALUATION				
	EXCEEDS EXPECTATIONS	MEETS EXPECTATIONS	NEEDS IMPROVEMENT	NOT VISIBLE
Describes the structure and composition of the Universe.				
Explain the source of a star's energy.				
Explains the concept of the Red Shift and how it used as an evidence for an expanding universe.				
Applies understanding of the Doppler effect to differentiate between source of sound in two movie clips				
Describes the cosmic microwave background radiation and its significance				
States the different hypotheses that preceded the Big Bang Theory of the origin of the universe				
Explain the origin and evolution of the Universe according to the Big Bang Theory.				

Additional Resources:

- (1) <http://science.nasa.gov/astrophysics/focus-areas/how-do-stars-form-and-evolve/> (accessed: 12 october 2015)
- (2) <http://csep10.phys.utk.edu/astr161/lect/solarsys/solarsys.html> (accessed 12 October 2015)
- (3) https://en.wikipedia.org/wiki/History_of_Solar_System_formation_and_evolution_hypotheses#Classification_of_the_theories (accessed 13 October 2015)
- (4) "The Origin of the Universe, Earth, and Life." National Academy of Sciences. *Science and Creationism: A View from the National Academy of Sciences, Second Edition*. Washington, DC: The National Academies Press, 1999. <http://www.nap.edu/read/6024/chapter/3#8> (accessed 2 October 2015)
- (5) <http://science.nasa.gov/astrophysics/focus-areas/what-powered-the-big-bang/> (accessed 5 October 2015)
- (6) Activities for teaching of the Universe: <http://www.nuffieldfoundation.org/science-society/activities-universe> and <http://molebash.com/doppler/horn/horn1.htm>
- (7) Short article: <http://www.scholastic.com/teachers/article/?origin-universe>

Lesson 2: Universe and the Solar System

Content Standard

The learners demonstrate an understanding of the formation of the universe and the solar system.

Learning Competencies

The learners shall be able to describe the different hypotheses explaining the origin of the solar system **(S11/12ES-la-e-2)** and explain the current advancements/information on the solar system **(S11/12ES-la-e-5)**

Specific Learning Outcomes

At the end of this lesson, the learners will be able to:

1. Identify the large scale and small scale properties of the Solar System;
2. Discuss the different hypotheses explaining the origin of the solar system; and
3. Become familiar with the most recent advancements/information on the solar system.

LESSON OUTLINE

Introduction	Communicating Learning Objectives	10
Motivation	Understanding the Origin and Evolution of the Solar System	5
Instruction	Lecture Proper and Discussion	35
Enrichment and Evaluation	Assignment	10

Materials

Projector or Print-out of Figures

Resources

- (1) <http://csep10.phys.utk.edu/astr161/lect/solarsys/solarsys.html> (accessed 12 October 2015)
- (2) https://en.wikipedia.org/wiki/History_of_Solar_System_formation_and_evolution_hypotheses#Classification_of_the_theories (accessed 13 October 2015)
- (3) "The Origin of the Universe, Earth, and Life." National Academy of Sciences. *Science and Creationism: A View from the National Academy of Sciences, Second Edition*. Washington, DC: The National Academies Press, 1999. <http://www.nap.edu/read/6024/chapter/3#8> (accessed 2 October 2015)
- (4) <http://science.nasa.gov/astrophysics/focus-areas/what-powered-the-big-bang/> (accessed 5 October 2015)
- (5) <http://abyss.uoregon.edu/~js/ast121/lectures/lec24.html>
- (6) (accessed 27 March 2016)
- (7) http://discovery.nasa.gov/education/pdfs/Active%20Accretion_Discovery_508.pdf (accessed 27 March 2016)
- (8) <http://www.pbslearningmedia.org/resource/nsn11.sci.ess.eiu.solarorigins/origins-of-the-solar-system/> (accessed 27 March 2016)
- (9) http://dawn.jpl.nasa.gov/DawnClassrooms/pdfs/ActiveAccretion_Dawn.pdf (accessed 27 March 2016)

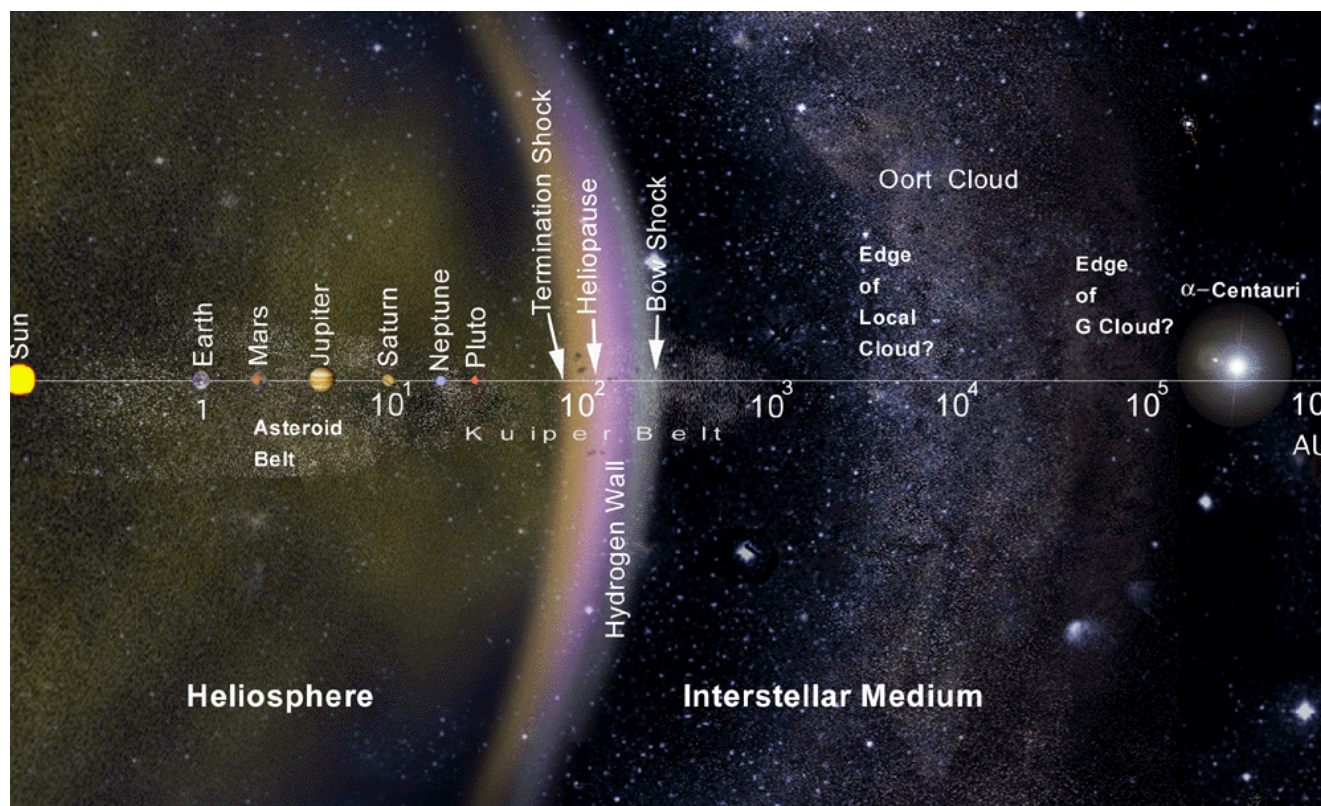
INTRODUCTION (10 MINS)

1. Introduce the following learning objectives:

At the end of this lesson, the learners will be able to:

- A. Identify the large scale and small scale properties of the Solar System;
- B. Discuss the different hypotheses explaining the origin of the solar system;
- C. Explain the significance of the most recent advancement/information on the Solar System.

2. Help learners recall what they have learned about the solar system by drawing a model on the board. Ask the learners for the correct sequence (from the inner planets to the outer planet).



Teacher Tips:

- The Solar System and its components have been discussed in Grade 6 and Grade 8 (astronomy)
- The solar system comprises the Sun, eight planets, dwarf planets such as Pluto, satellites, asteroids, comets, other minor bodies such as those in the Kuiper belt and interplanetary dust.
- The asteroid belt lies between Mars and Jupiter. Meteoroids are smaller asteroids. They are thought of as remnants of a “failed planet”—one that did not form due to disturbance from Jupiter’s gravity.
- The Kuiper belt lies beyond Neptune (30 to 50 AU, 1 AU = Sun-Earth distance = 150 million km) and comprise numerous rocky or icy bodies a few meters to hundreds of kilometers in size.
- The Oort cloud marks the outer boundary of the solar system and is composed mostly of icy objects

Source: Layout of the solar system comprising mainly the Sun, planets and their satellites, asteroids, and icy bodies such as dwarf planets and comets.

(<https://www.google.com.ph/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=0ahUKEwjue7soaTNAhUDGJQKHxjHAQ4QjBwIBA&url=https%3A%2F%2Fupload.wikimedia.org%2Fwikipedia%2Fcommons%2F9%2F9f%2FSolarmap.png&bvm=bv.124272578,d.dGo&psig=AFQjCNGwA4eXmalQjoCkVRqF4n4bDTC6sw&ust=1465881919469816>)

MOTIVATION (5 MINS)

Understanding the Origin and Evolution of the Solar System

1. The Earth, the planet we live on, is part of the Solar System.
2. If we want to know how the Earth formed, we need to understand the origin and evolution of the Solar System.

Teacher Tip:

Age of Solar System is at **4.6 billion** years old based on radioactive dating of meteorites (Solar System is much younger than the Universe);

INSTRUCTION (35 MINS)

Lecture Proper and Discussion

1. Show to the class the photos of the Milky Way galaxy and discuss the highlights.

Solar System

1. Overview
 - A. The solar system is located in the Milky Way galaxy—a huge disc- and spiral-shaped aggregation of about at least 100 billion stars and other bodies;
 - B. Its spiral arms rotate around a globular cluster or bulge of many, many stars, at the center of which lies a supermassive blackhole;
 - C. This galaxy is about 100 million light years across ($1 \text{ light year} = 9.4607 \times 10^{12} \text{ km}$);
 - D. The solar system revolves around the galactic center once in about 240 million years;
 - E. The Milky Way is part of the so-called Local Group of galaxies, which in turn is part of the Virgo supercluster of galaxies;
 - F. Based on the assumption that they are remnants of the materials from which they were formed, radioactive dating of meteorites, suggests that the Earth and solar system are 4.6 billion years old. on the assumption that they are remnants of the materials from which they were formed.

Large Scale Features of the Solar System

1. Much of the mass of the Solar System is concentrated at the center (Sun) while angular momentum is held by the outer planets.
2. Orbits of the planets elliptical and are on the same plane.
3. All planets revolve around the sun.
4. The periods of revolution of the planets increase with increasing distance from the Sun; the innermost planet moves fastest, the outermost, the slowest;
5. All planets are located at regular intervals from the Sun.

Small scale features of the Solar System

1. Most planets rotate prograde
2. Inner terrestrial planets are made of materials with high melting points such as silicates, iron, and nickel. They rotate slower, have thin or no atmosphere, higher densities, and lower contents of volatiles - hydrogen, helium, and noble gases.
3. The outer four planets - Jupiter, Saturn, Uranus and Neptune are called "gas giants" because of the dominance of gases and their larger size. They rotate faster, have thick atmosphere, lower densities, and fluid interiors rich in hydrogen, helium and ices (water, ammonia, methane).

Element Abundance on Earth, Meteorites, and Universe

1. The table below shows the abundance of elements across bodies in the solar system as compared to abundance in the universe.
 - A. Except for hydrogen, helium, inert gases, and volatiles, the universe and Earth have similar abundance especially for rock and metal elements.
 - B. The sun and the large planets have enough gravity to retain hydrogen and helium. Rare inert gases are too light for the Earth's gravity to retain, thus the low abundance.
 - C. Retention of volatile elements by the Earth is consistent with the idea that some materials that formed the Earth and the solar system were "cold" and solid; otherwise, the volatiles would have been lost. These suggest that the Earth and the solar system could be derived from materials with composition similar to that of the universe.
 - D. The presence of heavy elements such as lead, silver, and uranium on Earth suggests that it was

Teacher Tip:

- **Prograde** - counterclockwise when viewed from above the Earth's North Pole.
- Mercury's orbit around the sun does not conform with the rest of the planets in the solar system. It does not behave according to Newton's Laws.
- The precession or rotation of the orbit is predicted by Newton's theory as being caused by the pull of the planets on one another. The precession of the orbits of all planets except for Mercury's can, in fact, be understood using Newton's equations. But Mercury seemed to be an exception.
- As it orbits the Sun, this planet follows an ellipse, but only approximately: it is found that the point of closest approach of Mercury to the sun does not always occur at the same place as in other planets but that it slowly moves around the sun
- You can choose to skip this part (abundance of elements) if pressed for time.
- If you decide to discuss this part, you may show the table and solicit observations from the students as to the differences/similarities in terms of element composition (Not necessarily absolute amounts). Learners may also provide explanations/implications for their observations.

derived from remnants of a supernova and that the Sun is a second-generation star made by recycling materials.

Abundance of elements

Earth's origins known mainly from its compositional differences with the entire Universe. Planet-making process modified original cosmic material.

Elemental abundances in Earth vs. Universe (atoms per 10,000 atoms Silicon)

ROCK MAKERS		CONTINENTAL CRUST	UNIVERSE	METEORITES	WHOLE EARTH
	Si	10,000	10,000	10,000	10,000
	Al	3,000	950	740	740
	Fe	960	6,000	9,300	11,500
	Mg	940	9,100	9,700	9,700
	Ca	1,020	490	520	520
	Na	1,040	440	460	460
	K	540	30	40	40
	Mn	18	70	70	70
	Ti	104	20	20	20
	Ni	13	270	450	750
	P	35	100	60	60
	Cr	19	80	90	90

Expected responses may include:

- A difference between the composition of the Earth's continental crust and the Whole Earth (average composition of the Earth) P The Earth differentiated into compositional layers - crust, mantle, and the core
- Very similar rock and metal elements for Universe and Earth P easy to make Earth if most H and He are removed; sun and large planets have enough mass and gravity to retain H and He
- Inert gases rare on Earth P too light for Earth's gravity to hold
- Some volatile elements remain P ingredients from which Earth formed were "cold" and solid particles; if hot, would have been lost
- Recall that meteorites are believed to be remnants of materials from which the solar system was derived
- You can ask learners for what theories/ explanations they know about the origin of the solar system.

Elemental abundances in Earth vs. Universe (atoms per 10,000 atoms Silicon)

		CONTINENTAL CRUST	UNIVERSE	METEORITES	WHOLE EARTH
VOLATILES	H	1,400	4.0×10^9		84
	O	29,000	115,000	34,300	34,000
	N	1	66,000		0.2
	C	18	35,000		70
	S	9	3,750	990	1,100
	F	34	16		3
	Cl	4	90		30
INERT GASES	He		3.01×10^7		3.5×10^{-7}
	Ne		86,000		12×10^{-7}
	Ar		1,500		$5,900 \times 10^{-7}$
	Kr		0.51		0.6×10^{-7}

Teacher Tips:

- This is the nature of scientific inquiry. As new data is generated from observations/experimentation, a hypothesis can be revised or even replaced by a new one.
- Present the different hypotheses on the origin of the Solar System in table form. The first column is a summary of the hypothesis. Second column -flaws/drawbacks of the hypothesis.
- You can draw this simple diagram on the board to explain the Nebular Hypothesis.

Origin of the Solar System

Any acceptable scientific thought on the origin of the solar system has to be consistent with and supported by information about it (e.g. large and small scale features, composition). **There will be a need to revise currently accepted ideas should data no longer support them.**

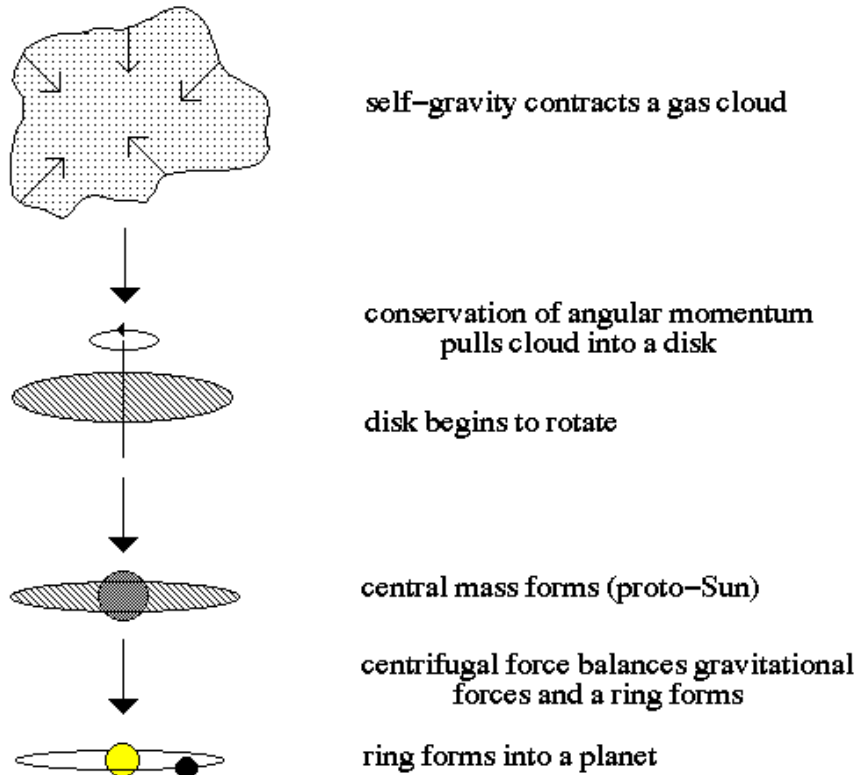
Rival Theories

Many theories have been proposed since about four centuries ago. Each has weaknesses in explaining all characteristics of the solar system. A few are discussed below.

Nebular Hypothesis

In the 1700s Emanuel Swedenborg, Immanuel Kant, and Pierre-Simon Laplace independently thought of a **rotating gaseous cloud that cools and contracts** in the middle to form the sun and the rest into a disc that become the planets. This nebular theory failed to account for the distribution of angular momentum in the solar system.

Nebular Hypothesis



Teacher Tips:

- The common theme of these hypotheses involves an **unlikely encounter** between the Sun and another celestial body (e.g. comet, star, protoplanet, interstellar cloud);
- The two major flaws of this type of hypothesis include: 1) fails to explain how planets are formed (hot gas from the sun/star expands and will not form planets); 2) this type of encounters are extremely rare

Source: Nebular Hypothesis (http://abyss.uoregon.edu/~js/images/nebular_hypothesis.gif)

Encounter Hypotheses:

- A. Buffon's (1749) **Sun-comet** encounter that sent matter to form planet;
- B. James Jeans' (1917) **sun-star** encounter that would have drawn from the sun matter that would condense to planets,
- C. T.C. Chamberlain and F. R. Moulton's (1904) **planetesimal hypothesis** involving a **star much bigger than the Sun passing by the Sun** and draws gaseous filaments from both out of which planetesimals were formed;
- D. Ray Lyttleton's (1940) sun's companion star colliding with another to form a **proto-planet** that breaks up to form Jupiter and Saturn.
- E. Otto Schmidt's accretion theory proposed that the Sun passed through **a dense interstellar cloud** and emerged with a dusty, gaseous envelope that eventually became the planets. However, it cannot explain how the planets and satellites were formed. The time required to form the planets exceeds the age of the solar system.
- F. M.M. Woolfson's capture theory is a variation of James Jeans' near-collision hypothesis. In this scenario, the Sun drags from a near proto-star a filament of material which becomes the planets. Collisions between proto-planets close to the Sun produced the terrestrial planets; condensations in the filament produced the giant planets and their satellites. Different ages for the Sun and planets is predicted by this theory.

Sun - Star interaction

Nobel Prize winner Harold Urey's compositional studies on meteorites in the 1950s and other scientists' work on these objects led to the conclusion that **meteorite constituents have changed very little since the solar system's early history and can give clues about their formation**. The currently accepted theory on the origin of the solar system relies much on information from meteorites.

Protoplanet Hypothesis - Current Hypothesis

- A. About 4.6 billion years ago, in the Orion arm of the Milky Way galaxy, a slowly-rotating gas and dust cloud dominated by hydrogen and helium starts to contract due to gravity
- B. As most of the mass move to the center to eventually become a proto-Sun, the remaining materials form a disc that will eventually become the planets and momentum is transferred outwards.
- C. Due to collisions, fragments of dust and solid matter begin sticking to each other to form larger and

Teacher Tips:

- Importance of meteorites in determining the age and the origin of the solar system.
- An improvement of the nebular hypothesis based on current knowledge of fluids and states of matter.
- Remind the learner of the comparison of the elemental abundance among the Universe, Meteorites, and the whole Earth
- Accretion and bombardment generate heat (kinetic energy is transformed to heat) which was partly retained by the Earth as **internal heat**

larger bodies from meter to kilometer in size. These **proto-planets** are **accretions** of frozen water, ammonia, methane, silicon, aluminum, iron, and other metals in rock and mineral grains enveloped in hydrogen and helium.

- D. High-speed collisions with large objects destroys much of the mantle of Mercury, puts Venus in retrograde rotation.
- E. Collision of the Earth with large object produces the moon. This is supported by the composition of the moon very similar to the Earth's Mantle
- F. When the proto-Sun is established as a star, its solar wind blasts hydrogen, helium, and volatiles from the inner planets to beyond Mars to form the gas giants leaving behind a system we know today.

Activity (Optional)

Let's Volt In

Activity/game based on Active Accretion NASA's Discovery and New Frontiers Program: http://dawn.jpl.nasa.gov/DawnClassrooms/pdfs/ActiveAccretion_Dawn.pdf

Recent advancement/information on the Solar System

Exploration of Mars

Since the 1960s, the Soviet Union and the U.S. have been sending unmanned probes to the planet Mars with the primary purpose of testing the planet's habitability. The early efforts in the exploration of Mars involved flybys through which spectacular photographs of the Martian surface were taken. The first successful landing and operation on the surface of Mars occurred in 1975 under the Viking program of NASA. Recently, NASA, using high resolution imagery of the surface of Mars, presented evidence of seasonal flow liquid water (in the form of brine - salty water) on the surface of Mars.

Rosetta's Comet

Rosetta is a space probe built by the European Space Agency and launched on 2 March 2004. One of its mission is to rendezvous with and attempt to land a probe (Philae) on a comet in the Kuiper Belt. One of the purpose of the mission is to better understand comets and the early solar systems. Philae landed successfully on comet (67P/Churyumov-Gerasimenko) on 12 November 2014. Analysis of the water (ice) from the comet suggest that its isotopic composition is different from water from Earth.

Teacher Tips:

- The activity/game can be very brief but it would entail preparation and a lot of space (ideally and outdoor activity).
- Surface features (e.g. canyons and drainage system) interpreted from the photographs of the surface Mars suggest the presence of flowing water in the past. (the importance of water to a planet's habitability will be discussed in the next lesson)
- Some scientists speculate that part of the water on the Earth's surface were brought by comets. The difference in isotopic composition of water suggest that this hypothesis is unlikely.
- Recall that objects in the solar system were subject to bombardment and collision early in the evolution of the solar system.
- The presence of craters is proof of this "violent past".
- On Earth, geologic processes have shaped and reshaped the surface removing evidence of cratering

Pluto Flyby

On 14 July 2015, NASA's New Horizon spacecraft provided mankind the first close-up view of the dwarf planet Pluto. Images captured from the flyby revealed a complex terrain - ice mountains and vast crater free plains. The presence of crater free plains suggests recent (last 100 millions of years) of geologic activity.

ENRICHMENT

Is the Solar System unique or rare? What is the possibility of finding a similar system within the Milky Way Galaxy? What about an Earth like planet?

Teacher Tips:

- Recent works are reporting presence of a solar system in the other part of the galaxy. Ask learners to think about the questions and do some research. This can also be used to transition to the next topic - Earth as habitable planet.
- Criteria for assessment of this task may include: Logical discussion on answering the questions with supporting statements based on scientific concepts.

EVALUATION				
	EXCEEDS EXPECTATIONS	MEETS EXPECTATIONS	NEEDS IMPROVEMENT	NOT VISIBLE
Name the different components of the solar system.				
Name the large scale and small scale features of the solar system.				
Discuss the different hypotheses regarding the origin of the solar system and recognizing their weaknesses.				
Discuss the origin and evolution of the solar system based on the most current hypothesis (Proto Planet Hypothesis)				
Enumerate the most recent advancements in the understanding of the Solar System				

Lesson 3: Universe and the Solar System

Content Standard

The learners demonstrate an understanding of the formation of the universe and the solar system.

Learning Competency

The learners shall be able to recognize the uniqueness of Earth, being the only planet in the solar system with properties necessary to support life.

(S11/12ES-Ia-e-3)

Specific Learning Outcomes

At the end of this lesson, the learners will be able to:

1. Recognize the difference in the physical and chemical properties between the Earth and its neighboring planets; and
2. Identify the factors that allow a planet to support life.

LESSON OUTLINE

Introduction	Communicating Learning Objectives	10
Motivation	4 Picture - 1 Word	5
Instruction	Lecture Proper and Discussion	45
Enrichment and Evaluation	Essay on Terraforming	
Materials	Projector or Print-out of Figures	
Resources	(1) http://www.voyagesthroughtime.org/planetary/sample/lesson5/z_act3.htm (2) http://www.voyagesthroughtime.org/planetary/sample/lesson5/pdf/goldilocks.pdf (3) http://www.voyagesthroughtime.org/planetary/sample/lesson5/pdf/5_3_1sas_crashland.pdf (4) https://btc.montana.edu/ceres/html/Habitat/habitablezone.htm (5) http://nssdc.gsfc.nasa.gov/planetary/factsheet/	

INTRODUCTION (10 MINS)

1. Introduce the following learning objectives :
2. At the end of this lesson, the learners will be able to:
 - A. Recognize the difference in the physical and chemical properties between the Earth and its neighboring planets.
 - B. Identify the factors that allow a planet to support life.
3. Review previous lesson on the Solar System:
 - A. Origin
 - B. Components
 - C. Terrestrial vs Gas Planets

MOTIVATION (5 MINS)

Four pictures one word

Ask the students to guess the four letter word. "L I F E"

Man's failure to protect the environment and therefore LIFE here on Earth is perhaps due to:

1. Inability to recognize the full consequence of his/her actions;
2. Lack of appreciation of how truly unique the Earth is.

The humanity's failure to protect the environment and **life** here on Earth is likely due to the following:

1. Inability to recognize the full consequence of his/her actions
2. Lack of appreciation of how truly unique the Earth is

Teacher tip

The concept of the Earth as a system and the interconnectivity of its components will be discussed in the succeeding lesson.

Teacher tip

Teacher can create his or her own 4 Pictures 1 Word puzzle. Use images that the learners can easily relate to.



Teacher tip

The concept of the Earth as a system and the interconnectivity of its components will be discussed in the succeeding lesson.

INSTRUCTION/PRACTICE (45 MINS)

Activity 1: Compare and Contrast. What are the similarities and differences among these three terrestrial planets?

Venus

Earth

Mars



Figure 1. Venus, Earth, and Mars. Images from NASA.

1. Print and cut-out photographs of terrestrial planets Venus, Earth, and Mars. Place photographs side by side.
2. Divide the class into groups of 3 to 5. Give each group a copy of Table 1 for reference. Ask each group to write down on a piece of paper similarities and differences among the planets. Give the students 15 minutes to complete the task.
3. Ask the learners to provide possible explanations for their observations using the information in Table 2, together with previous knowledge about the planets.
4. After the task, ask a representative from each group to present their observations.

Teacher Tips:

- To save time, prepare before the class starts.
- Try to print colored photographs in hard paper (so it can be used several times). Print the photographs in the correct scale.
- Alternatively, the teacher may opt to post on the blackboard the contents of Table 2 instead of giving out copies to the learners.

Possible responses may include:

- The color blue for Earth is significant - liquid water. The size difference/similarity is also important.
- Similar size and mass of Venus and Earth. Mars is about half the Earth's size.
- All the three planets have spheroidal shape.
- Rows color coded to indicate relationship.
- **Escape velocity** - minimum speed an object needs to escape a planet's pull of gravity.
- **Surface pressure** - atmospheric pressure at a location on the surface of the planet. It is proportional to the mass of air above the location
- **Temperature if no GHG** - this would be the temperature of the planet without the warming effect of green house gases. Note that the temperature of the Earth would be ~ 18 °C lower without green house warming.
- Emphasize to the students that the green house effect is not necessarily undesirable. It is run-away green house effect which we would like to avoid (e.g. Venus).

Table 1. Venus, Earth, Mars Comparison(modified from <http://nssdc.gsfc.nasa.gov/planetary/factsheet/>)

	VENUS	EARTH	MARS
Mass (1,024 kg)	4.87	5.97	0.642
Diameter (km)	12,104	12,756	6,792
Density (kg/m ³)	5,243	5,514	3,933
Gravity (m/s ²)	8.9	9.8	3.7
Escape Velocity (km/s)	10.4	11.2	5
Surface Pressure (bars)	92	1	0.01
Composition of Atmosphere	96% CO ₂ 3.5% N	77% N 21% O ₂ 1% Ar	95 % CO ₂ 2.7% N 1.6% Ar
Major Greenhouse Gases (GHG)	CO ₂	CO ₂ H ₂ O	CO ₂
Mean Temperature (C)	464	15	-65
Temperature if no GHG	-46	-18	-57
Change in Temperature (C) due to GHG	+ 523	+ 33	+ 10
Distance from Sun (10 ⁶ km)	108.2	149.6	227.9
Orbital Period (days)	224.7	365.2	687
Orbital Velocity (km/s)	35	29.8	24.1
Length of Day (hours)	2,802	24	24.7
Global Magnetic Field	No	Yes	No

Teacher Tips:

- Rows color coded to indicate relationship.
- **Escape velocity** - minimum speed an object needs to escape a planet's pull of gravity.
- **Surface pressure** - atmospheric pressure at a location on the surface of the planet. It is proportional to the mass of air above the location
- **Temperature if no GHG** - this would be the temperature of the planet without the warming effect of green house gases. Note that the temperature of the Earth would be ~ 18 °C lower without green house warming.
- Emphasize to the students that the green house effect is not necessarily undesirable. It is run-away green house effect which we would like to avoid (e.g. Venus).
- Ask the students what is the consequence if there was not GHG effect.
- **Length of day** - a function of rotational speed.
- The **Earth's magnetic field** is believed to be the consequence of the presence of a solid metallic inner core and a liquid metallic outer core. (Topic to be discussed in succeeding lessons - Earth's Interior.
- The ability of a planet to retain its **internal heat** is proportional to its **size**. Mars may have lost much of its internal heat very early in its evolution.
- A planet's **temperature** is a function of distance from the Sun but is modified by the amount of greenhouse warming.

1. Venus, Earth, and Mars are part of the inner terrestrial or "rocky" planets. Their composition and densities are not too different from each other.
2. Venus is considered to be the Earth's twin planet. It has a very similar size and mass with the Earth. Mars is about half the Earth's size.
3. Orbital period and velocity are related to the planet's distance from the sun. Among the three planet, Venus is the nearest and Mars is the farthest from the Sun.
4. Rotational speed of Earth and Mars are very similar. Rotational speed of Venus is extremely slow.
5. Abundance of liquid water on Earth, hence the blue color. The Earth is a habitable planet.

Activity 2. Interstellar Crash Landing

1. Ask students what factors would make a planet habitable. Learners should try to elaborate on their responses. (adapted from: http://www.voyagethroughtime.org/planetary/sample/lesson5/pdf/5_3_1sas_crashland.pdf)
2. Provide a copy of Table 2 - "Factors that Make a Planet Habitable" to each of the group (can be the same grouping as Activity 1). Ask students to read the document carefully and compare their answers they have given at the start of the activity

Table 2. Factors that Make a Planet Habitable (http://www.lpi.usra.edu/education/explore/our_place/hab_ref_table.pdf)

Teacher Tips:

- **Water** - in the liquid form, turns out to be one of the most important prerequisites for life as we know it.
- There is recent evidence that liquid water, in the form of brine (salty water) flows intermittently on the surface of Mars.
- **Thermophiles** - bacteria that can tolerate extreme temperatures (41 to 122 °C) commonly associated with hot springs and deep-sea hydrothermal vents. Life, in general can tolerate a wide range of temperature conditions. The temperature range that allows water to exist in the liquid state is the over-riding factor.
- Planets should have **sufficient size** to hold a **significant atmosphere**. The composition of the atmosphere, specifically the amount of **green house gases**, influences the planet **surface temperature**.
- The amount of **solar radiation** that a planet receives is primarily a function of distance from the sun. **Sunlight** is essential for **photosynthesis** but some organism are able to extract energy from other sources (**chemosynthetic organisms**).
- A system that will be able to constantly supply nutrients to organisms is important to sustain life. On Earth, nutrients are cycled through the hydrologic cycle and plate tectonics (volcanism)
- Internal heat drives plate tectonics. The ability of a planet to maintain internal heat is related to size.
- The document/table can be downloaded from http://www.lpi.usra.edu/education/explore/our_place/hab_ref_table.pdf

Factors that make a Planet Habitable	Not Enough of the Factor	Just Right	Too Much of the Factor	Situation in the Solar System
Temperature influences how quickly atoms and molecules move.	Low temperatures cause chemicals to react slowly, which interferes with the reactions necessary for life. It can also cause the freezing of water, making liquid water unavailable.	Life seems to be limited to a temperature range of -15oC to 115oC. In this range, liquid water can still exist under certain conditions.	At about 125oC, protein and carbohydrate molecules, and the genetic material (e.g., DNA and RNA) start to break apart. Also, high temperatures cause the quick evaporation of water.	Surface: only the Earth's surface is in this temperature range. Sub-surface: the interior of the solid planets and moons may be in this temperature range.
Atmosphere Traps heat, shields the surface from harmful radiation, and provides chemicals needed for life, such as nitrogen and carbon dioxide.	Small planets and moons have insufficient gravity to hold an atmosphere. The gas molecules escape to space, leaving the planet or moon without an insulating blanket or a protective shield.	Earth & Venus are the right size to hold a sufficient-sized atmosphere. Earth's atmosphere is about 100 miles thick. It keeps the surface warm & protects it from radiation & small- to medium-sized meteorites.	Venus's atmosphere is 100 times thicker than Earth's. It is made almost entirely of greenhouse gasses, making the surface too hot for life. The four giant planets are completely made of gas.	Of the solid planets & moons, only Earth, Venus, & Titan have significant atmospheres. Mars' atmosphere is about 1/100th that of Earth's, too small for significant insulation or shielding.
Energy Organisms use light or chemical energy to run their life processes.	When there is too little sunlight or too few of the chemicals that provide energy to cells, such as iron or sulfur, organisms die.	With a steady input of either light or chemical energy, cells can run the chemical reactions necessary for life.	Light energy is a problem if it makes a planet too hot or if there are too many harmful rays, such as ultraviolet. Too many energy-rich chemicals is not a problem	Surface: The inner planets get too much sunlight for life. The outer planets get too little. Sub-surface: Most solid planets & moons have energy-rich chemicals.
Nutrients Used to build and maintain an organism's body.	Without chemicals to make proteins & carbohydrates, organisms cannot grow. Planets without systems to deliver nutrients to its organisms (e.g., a water cycle or volcanic activity) cannot support life. Also, when nutrients are spread so thin that they are hard to obtain, such as on a gas planet, life cannot exist.	All solid planets & moons have the same general chemical makeup, so nutrients are present. Those with a water cycle or volcanic activity can transport and replenish the chemicals required by living organisms.	Too many nutrients are not a problem. However, too active a circulation system, such as the constant volcanism on Jupiter's moon, Io, or the churning atmospheres of the gas planets, interferes with an organism's ability to get enough nutrients.	Surface: Earth has a water cycle, an atmosphere, and volcanoes to circulate nutrients. Venus, Titan, Io, and Mars have nutrients and ways to circulate them to organisms. Sub-surface: Any planet or moon with sub-surface water or molten rock can circulate and replenish nutrients for organisms

1. You may also require the learners to include a sketch/diagram of how they think their habitable planet/moon would look like based on the factors for habitable planet/moon.
2. Ask the students to imagine themselves in an interstellar voyage. Their spaceship suffers mechanical problems and will be forced to land. Fortunately they are passing through the YanibSystem, which is composed of a sun-like star surrounded by seven planets, some of which have moons. The profiles of planets and moons of the Yanib System are listed on Table 3 (Provide each group a copy of Table 3). Students are to decide the best place to land their ship.
3. Ask students to write down on a piece of paper their choice of planet or moon. Reasons for their choice should also be written down. Reasons why they did not choose the other planets should also be included.

Table 3 Profiles of Planets and Moons of Yanib System. Modified from: http://www.voyagesthroughtime.org/planetary/sample/lesson5/pdf/5_3_1sas_crashland.pdf

Planet 1 (closest to the star) Mass: 1.5 (Earth = 1) Tectonics: Active volcanoes and seismic activity detected Atmosphere: CO₂, N, and H₂O Ave. Temperature: 651°C Description: Thick clouds surround the planet. No surface is visible through the clouds.	Planet 2 Mass: 0.5 Tectonics: No activity detected Atmosphere: Thin CO₂ atmosphere detected Average Temperature: 10°C Description: Polar ice caps, dry riverbeds	Planet 3 Mass: 1 Tectonics: Active volcanoes and seismic activity detected. Atmosphere: CO₂, H₂O Temperature: 30 °C Description: Liquid water oceans cover much of the surface. Volcanic island chains make up most of the dry land.	Planet 4 Mass: 1.5 Tectonics: Active volcanoes and seismic activity detected Atmosphere: N, O₂, and ozone layer Average Temperature: 2°C Description: Cold oceans, covered with ice along much of the globe, some open water around equator
Planet 5 Gas Giant with one large moon. Moon: Sulfur dioxide (SO₂) atmosphere. Many volcanoes and hot springs on surface. Temperatures in hot spots can be up to 600°C. Other spots away from volcanic heat can get as low in temperature as 145°C.	Planet 6 Gas giant with four large, rocky satellites (moons). Moons have no appreciable atmosphere. Ice detectable on one.	Planet 7 (furthest from the star) Gas giant with two large moons. Moon 1: Thick methane atmosphere with pressure high enough to keep a potential methane ocean liquid underneath. Temperature: -200 °C Moon 2: Covered in water ice. Ice appears cracked and re-frozen in parts, indicating a potential liquid ocean underneath. Surface temperature -100 °C.	

ENRICHMENT

Terraforming Mars

Have the learners write a 200 word report/essay on the following topic: 'Can man alter Mars environment to make it more suitable for human habitation? How?'

Teacher tip

- To **terraform** means to transform another planet to resemble the Earth in several aspects, specifically the ability to support life.
- Use the following criteria in assessing this assignment:
 - Logic and consistency in the arguments
 - Valid and consistent scientific concepts to support the answer

	NOT VISIBLE	NEEDS IMPROVEMENT	MEETS EXPECTATIONS	EXCEEDS EXPECTATIONS
Identify similarities and differences among the three planets, namely Venus, Earth, and Mars.				
Explain the impact of planet size to gravity, internal heat, and atmosphere of the planet.				
Identify factors that influence a planet's temperature.				
Explain factors that make a planet habitable.				
Explain why the presence of liquid water is important to life				

Lesson 4: Earth Subsystems

Content Standard

The learners shall be able to understand the subsystems (geosphere, hydrosphere, atmosphere, and biosphere) that make up the Earth.

Learning Competencies

The learners shall be able to explain that the Earth consists of four subsystems, across whose boundaries matter and energy flow **(S11/12ES-Ia-e-4)** and show the contributions of personalities/people on the understanding of Earth Systems **(S11/12ES-Ia-e-6)**.

Specific Learning Outcomes

At the end of this lesson, the learners will be able to:

1. Define the concept of a system;
2. Recognize the Earth as a system composed of subsystems; and
3. Discuss the historical development of the concept of Earth System.

LESSON OUTLINE

Pre-Class Activity	Optional Activities based on Class Setting	30
Introduction	Communicating Learning Objectives	5
Motivation	Class Sharing	5
Instruction	The Earth System	30
Enrichment and Evaluation	Take Home Essay	20

Materials

Pencil/Drawing Material, A4 or Letter size Paper, Clip Board or any flat surface that can be used for drawing

Resources

- (1) Earth Systems. <http://serc.carleton.edu/earthlabs/climate/index.html>
<https://www.google.com.ph/webhp?sourceid=chrome-instant&ion=1&espv=2&ie=UTF-8#q=earth+systems>
- (2) Earth Systems. http://www.esrl.noaa.gov/gmd/outreach/lesson_plans/Teacher%20Background%20Information-%20The%20Major%20Earth%20Spheres.pdf
- (3) Hydrologic Cycle. http://www.esrl.noaa.gov/gmd/outreach/lesson_plans/The%20Hydrologic%20Cycle.pdf
- (4) El Niño Phenomenon. <http://www.esrl.noaa.gov/gmd/obop/mlo/educationcenter/students/brochures%20and%20diagrams/noaa%20publications/El%20Nino%20Fact%20Sheet.pdf>
- (5) Video Daisy World Model. <https://www.youtube.com/watch?v=cW4JTHz1aRg>

PRE-CLASS ACTIVITY (30 MINS)

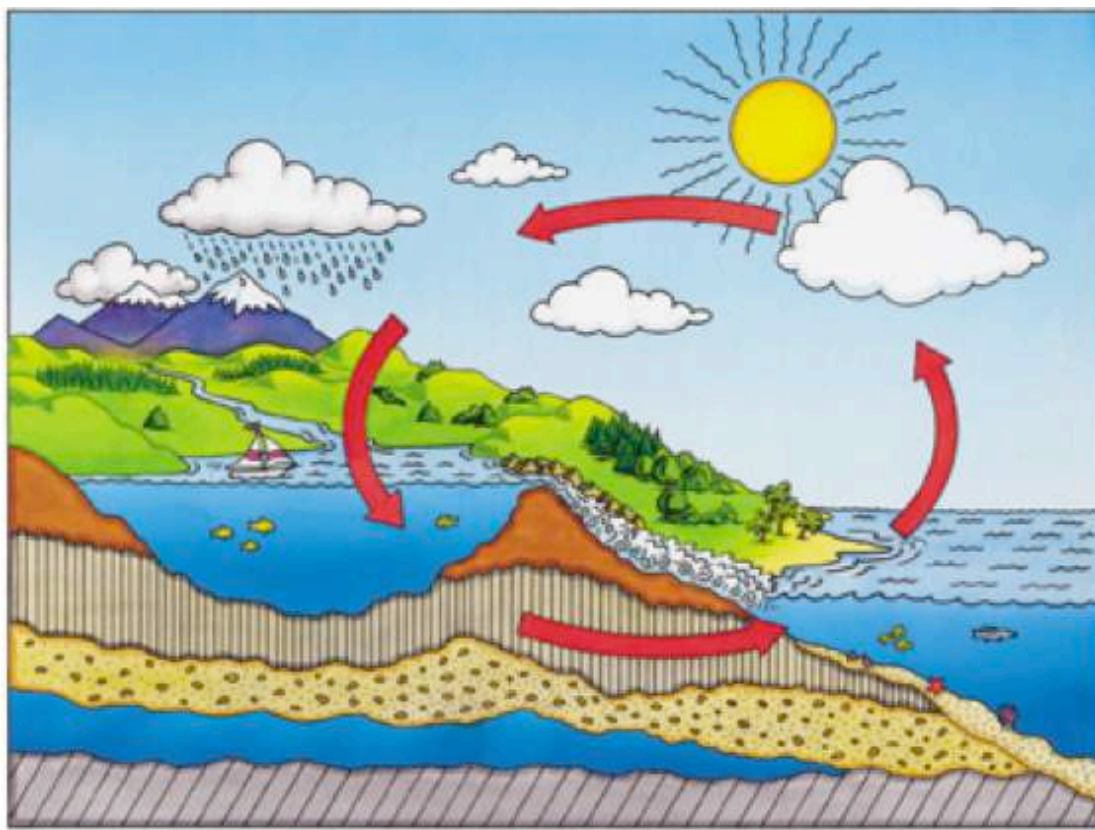
1. Perform either one of the following pre-class activities.

A. Option 1 (This option is recommended for schools in a non-urban setting.)

- i. Using a pencil and a piece of paper, have the learners draw or illustrate the field area. Take note of the presence of vegetation, soil cover, wildlife, rockout-crops, and bodies of water.
- ii. Ask the learners to think how energy and mass are transferred in the different components of the area.

B. Option 2 (This option is recommended for schools in an urban setting.)

- i. Together with the learners, label the different processes and phases of water involved in the water cycle.



Teacher tip

- Check your immediate surrounding for an appropriate field area, preferably with trees or vegetation, and pond, lake, or stream.
- Before bringing the learners to the field area, check for potential hazards. If applicable, the learners should be properly warned about safety precautionary measures.
- For schools in urban areas without open spaces, choose option 2.

Teacher tip

- The concept of ecosystems has been discussed in pre-SHS biology. Emphasize the definition of the word interaction.
- Most of the terms in this lesson have been introduced in previous science subjects.
- Help the learners integrate the concepts that will be introduced.

Figure 1: Hydrologic Cycle (w/o labels)

Image Source: http://3.bp.blogspot.com/_YTb6ZbIJu0o/TPMzp32R5aI/AAAAAAAAALg/vnul9ZgWt0M/s1600/WaterCycleArt.jpg

C. Use the following terms to complete the cycle:

- i. condensation
- ii. precipitation
- iii. evaporation
- iv. transpiration
- v. infiltration
- vi. surface run-off

INTRODUCTION (5 MINS)

1. Introduce the following learning objectives using any of the suggested protocols(Verbatim, Own Words, Read-aloud)
 - A. I can identify and explain each of the subsystems of the Earth;
 - B. I can explain how these subsystems interact.
 - C. I am familiar with the historic development of the concept of "Earth System"
2. Ask the students what they remember about the concept of Ecosystems.

MOTIVATION (5 MINS)

1. Ask the students what they know or have experienced regarding El Niño.
2. Use the Figure 2, briefly explain the El Niño phenomenon. Emphasize that it starts with the unusual warming of the central Pacific Ocean accompanied by the weakening of the trade winds. The warming of the central Pacific Ocean results to an eastward shift of the low pressure area (away from the Indo Pacific).

Teacher tip

- The concept of Ecosystems has been discussed in middle high school biology. Emphasize the word "interaction".
- Most of the terms to be used in this lesson have been introduced in previous science subjects.
- The challenge to the teacher is to help students to integrate concepts and explore relationships.
- Most of the answers will describe atmospheric conditions e.g. hot and dry, no rain, water crisis etc.
- Point out that an El Niño is not limited to atmospheric conditions. It is the result of ocean (hydrosphere)-atmosphere interaction.
- The subsystems of the Earth (Atmosphere, Hydrosphere, Biosphere, and Lithosphere) interact with each other.

THE EL NIÑO PHENOMENON

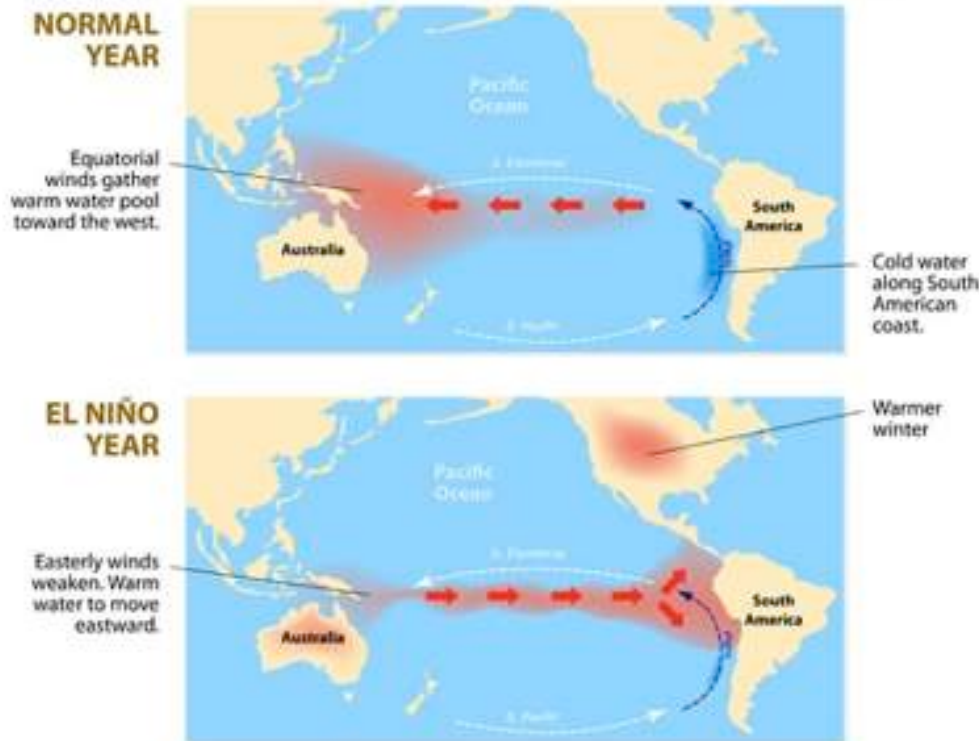


Figure 2. El Niño phenomenon

Source: <http://images.listlandcom.netdna-cdn.com/wp-content/uploads/2015/09/The-El-Nino-Phenomenon-explained-in-a-nice-little-graphic.jpg>

3. Explain the origin of the term '**El Niño**' as a decrease in fish catch off the coast of Peru near Christmas time. Emphasize that this is a biologic response.

Teacher tip

- Most of the answers will describe the atmospheric conditions during El Niño (e.g. hot and dry, no rain, water crisis, etc.)
- Emphasize that El Niño is not limited to atmospheric conditions. It is the result of hydrosphere (ocean)-atmosphere interaction.
- The subsystems of the Earth (atmosphere, hydrosphere, biosphere, and lithosphere) interact with each other.

INSTRUCTION (30 MINS)

1. Definition of a System
 - A. A set of interconnected components that are interacting to form a unified whole.
2. Components or subsystems of the Earth System.
 - A. Use a projector or draw on the board a diagram (below) to enumerate the subsystems of the Earth.

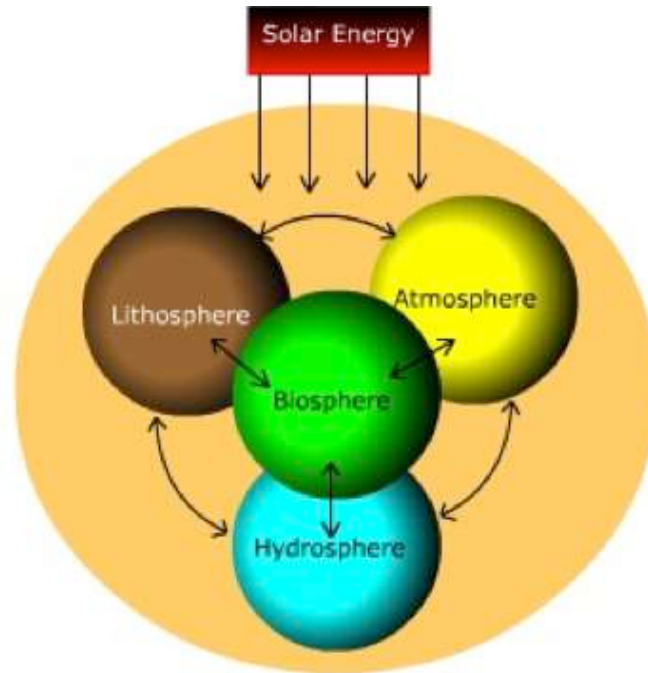


Figure 3: The Earth system. (Source: <https://www.earthonlinemedia.com>)

3. Explain that the Earth system is essentially a closed system. It receives energy from the sun and returns some of this energy to space.

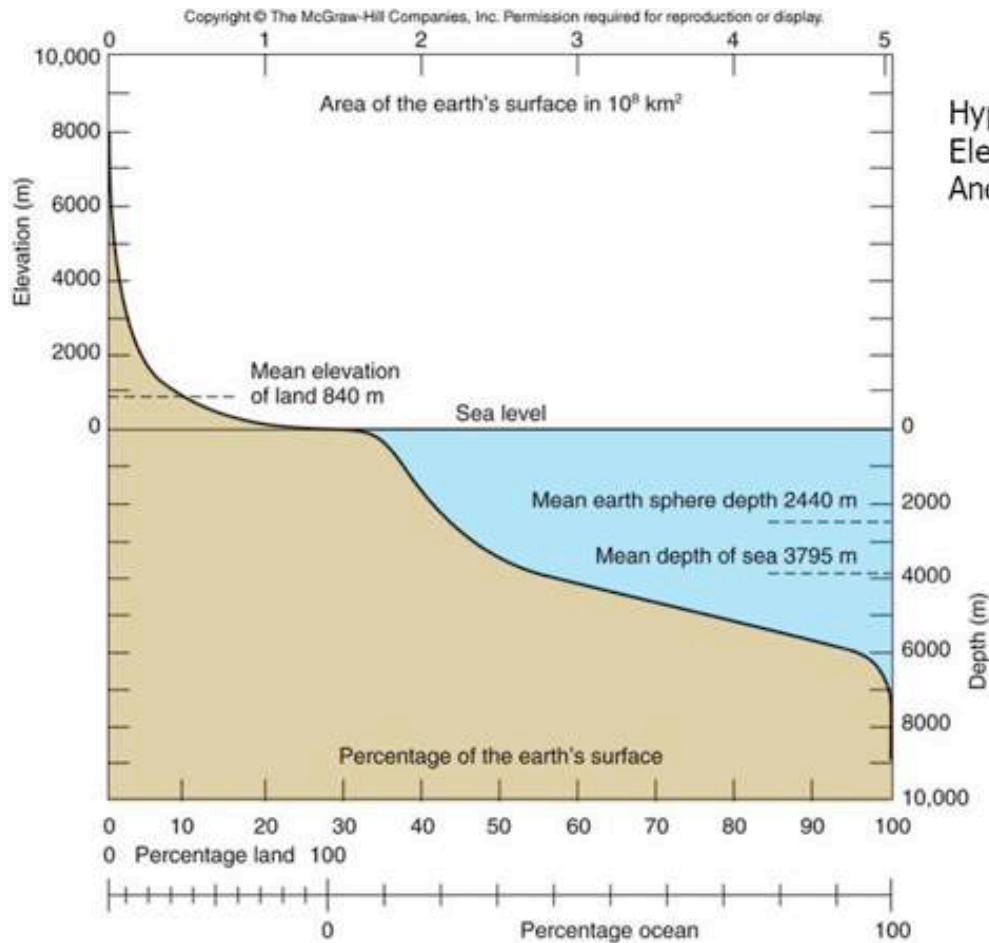
Teacher tips:

- Give the government as an example. Inquire about the three branches of the government (executive, judiciary, and legislative). Explain that these three branches are independent and have their respective mandates or functions. A government can only succeed if all three branches are able to perform their respective functions.
- The arrows in the diagram indicate the interaction among the components.
- A closed system is a system in which there is only an exchange of heat or energy and no exchange of matter.

4. Introduce the term **atmosphere**.
 - A. The atmosphere is the thin gaseous layer that envelopes the lithosphere.
 - B. The present atmosphere is composed of 78% nitrogen (N), 21% oxygen (O₂), 0.9% argon, and trace amount of other gases.
 - C. One of the most important processes by which the heat on the Earth's surface is redistributed is through atmospheric circulation.
 - D. There is also a constant exchange of heat and moisture between the atmosphere and the hydrosphere through the hydrologic cycle.
5. Introduce the term **lithosphere**.
 - A. The lithosphere includes the rocks of the crust and mantle, the metallic liquid outer core, and the solid metallic inner core.
 - B. Briefly discuss the Plate Tectonics as an important process shaping the surface of the Earth. The primary driving mechanism is the Earth's internal heat, such as that in mantle convection.
6. Introduce the term **biosphere**.
 - A. The biosphere is the set of all life forms on Earth.
 - B. It covers all ecosystems—from the soil to the rainforest, from mangroves to coral reefs, and from the plankton-rich ocean surface to the deep sea.
 - C. For the majority of life on Earth, the base of the food chain comprises photosynthetic organisms. During **photosynthesis**, CO₂ is sequestered from the atmosphere, while oxygen is released as a byproduct. The biosphere is a CO₂ sink, and therefore, an important part of the **carbon cycle**.
 - D. Sunlight is not necessary for life.
7. Introduce the term **hydrosphere**.
 - A. About 70% of the Earth is covered with liquid water (hydrosphere) and much of it is in the form of ocean water (Figure 3).
 - B. Only 3% of Earth's water is fresh: two-thirds are in the form of ice, and the remaining one-third is present in streams, lakes, and groundwater.

Teacher tips:

- Describe each subsystem of the Earth.
- Warm air converges and rises to form low-pressure zones. Low-pressure areas are associated with increased precipitation. By contrast, cold air descends to form high-pressure regions (dry regions).
- The concept of Plate Tectonics will be discussed in detail in the succeeding lessons (Internal Structure of the Earth)
- The carbon cycle is the process by which carbon is transferred among the atmosphere, oceans, soil, and living organisms.
- Isolated and complex ecosystems thrive in the deep sea floor at depths beyond the reach of sunlight. The base of the food chain for such ecosystems is called **chemosynthetic** organisms. Instead of sunlight, these organisms use energy from **hydrothermal vents** or **methane seeps** (methane seeping through rocks and sediments) to produce simple sugars.



Hypsographic Curve
Elevation areas above
And below sea-level

Teacher tips:

- The hypsographic curve is a graphical representation of the proportion of land at various elevations (meters above or below sea level)
- Make sure that the students understand what the X and Y axis represents. To test comprehension, ask the students what proportion of the Earth's surface is about 4000m below sea level (~ 60 %)
- The hydrologic cycle (water cycle) has been partly discussed in Grade 4 (water in the environment) and Grade 8 (Ecosystems).
- Through the process of weathering and erosion, the hydrologic cycle is another important process contributing to the shaping and reshaping the surface of the Earth. This is an important link between the hydrosphere, atmosphere and lithosphere that the student should be able to identify.

- C. The oceans are important sinks for CO_2 through direct exchange with the atmosphere and indirectly through the weathering of rocks.
- D. Heat is absorbed and redistributed on the surface of the Earth through ocean circulation.

8. The origin of the systems approach to the study of the Earth
- A. One of the first scientist to push for a more integrated or holistic approach in the understanding of the universe (and by extension the Earth) was **Friedrich Wilhelm Heinrich Alexander von Humboldt**. He considered the universe as one interacting entity.
 - B. The term "**biosphere**" was popularized by **Vladimir Vernadsky** (1863-1945), a Russian - Ukranian scientist who hypothesized that life is a geological force that shapes the Earth.
 - C. In the 1970s, the **Gaia Hypothesis** was jointly developed by James Lovelock, an English scientist/naturalist, and Lynn Margulis, an American microbiologist. According to the Gaia Hypothesis. the biosphere is a self-regulating system that is capable of controlling its physical and chemical environment.
 - D. In 1983, **NASA** advisory council established the **Earth Systems Science Committee**. The committee, chaired by **Moustafa Chahine**, published a ground breaking report *Earth System Science: A Program For Global Change* in 1988. For the first time, scientist were able to demonstrate how the many systems interact.

Teacher tips:

- To illustrate how a living organism is capable of self regulation, ask the students how their bodies react to outside temperature.
- When it is hot, we sweat. Evaporation of the sweat cools down our skin. When it is cold, we shiver. The mechanical shaking of the body when we shiver releases heat
- Use the pre-lecture drawing exercise for schools with open spaces (option 1); else, use the hydrologic cycle diagram

PRACTICE (20 MINS)

- 1. Using the illustration diagram (option 1 or 2), identify how energy and mass is exchanged among the subsystems. Maybe use different types of line .boxes to differentiate between matter / materials and energy?
- 2. Use arrows to indicate interaction between components.

ENRICHMENT

- 1. James Lovelock used the "Daisy World Model" to illustrate how the biosphere is capable of regulating its environment.
- 2. Ask the students to research and write a two page report (50 to 100 words, with illustrations) on the "Daisy World Model" of James Lovelock.

Teacher tips:

A simple explanation of the Daisy World Model can be viewed in: <https://www.youtube.com/watch?v=cW4JTHz1aRg>

EVALUATION				
	NOT VISIBLE	NEEDS IMPROVEMENT	MEETS EXPECTATIONS	EXCEEDS EXPECTATIONS
Understands the concept of a system.				
Can describe the different components or subsystems of the Earth System.				
Can identify and explain how mass and energy is exchanged among the components of a system.				
Essay is relevant to the assigned topic and written logically and clearly.				

Lesson 5: The Internal Structure of the Earth

Content Standard

The learners will be able to develop and demonstrate an understanding of the internal structure of the Earth.

Learning Competencies

The learners shall be able to identify the layers of the Earth **(S11/12ES-la-e-7)** and differentiate the layers of the Earth from each other **(S11/12ES-la-e-8)**.

Specific Learning Outcomes

At the end of this lesson, the learners will be able to:

1. Describe the Earth's interior (in terms of crust, mantle, core); and
2. Compare the Earth's layers

LESSON OUTLINE

Introduction	Presentation of objectives and terms	5
Motivation	Bell ringer question to activate prior knowledge	10
Instruction	Lecture proper and discussion	25
Enrichment	Lab activity on constructing a scale model of the Earth's interior	45
Evaluation	Drawing cross sections of Earth from memory	20

Resources

- (1) http://agi.seaford.k12.de.us/sites/rsalisbury/BioLit%202_3/Earth%20Systems/Earth's%20Interior/Egg-Earth%20Structure%20Lab.pdf

INTRODUCTION (5 MINS)

1. Introduce the following learning objectives and important terms
 - A. I can identify the layers of the Earth
 - B. I can differentiate the layers of the Earth from each other
2. Introduce the list of important terms that learners will encounter.
 - A. Crust – thin, outermost layer of the Earth; is of two different types: continental crust and oceanic crust
 - B. Mantle – middle layer of the earth between the crust and the core; makes up about 83% of Earth's interior
 - C. Core – innermost layer of the earth; outer core is in a liquid state whereas inner core is in solid state
 - D. Lithosphere – rigid outer layer of the layer which is made up of the brittle crust and upper mantle
 - E. Asthenosphere – layer of weak, ductile rock in the mantle; situated below the lithosphere
 - F. Moho – boundary separating the crust and the mantle
 - G. Seismic wave – an elastic shock wave that travels outward in all directions from an earthquake source
 - H. Convection – transfer of heat by mass movement or circulation of a substance
 - I. Plate tectonics – theory which proposes that the earth's crust and upper mantle to be composed of several large, thin, and relatively rigid plates that move relative to one another
3. Have the students define in their own words what they know of the terms. Write their responses on the board. Leave student responses up and refer to these throughout the lesson.

Teacher Tip:

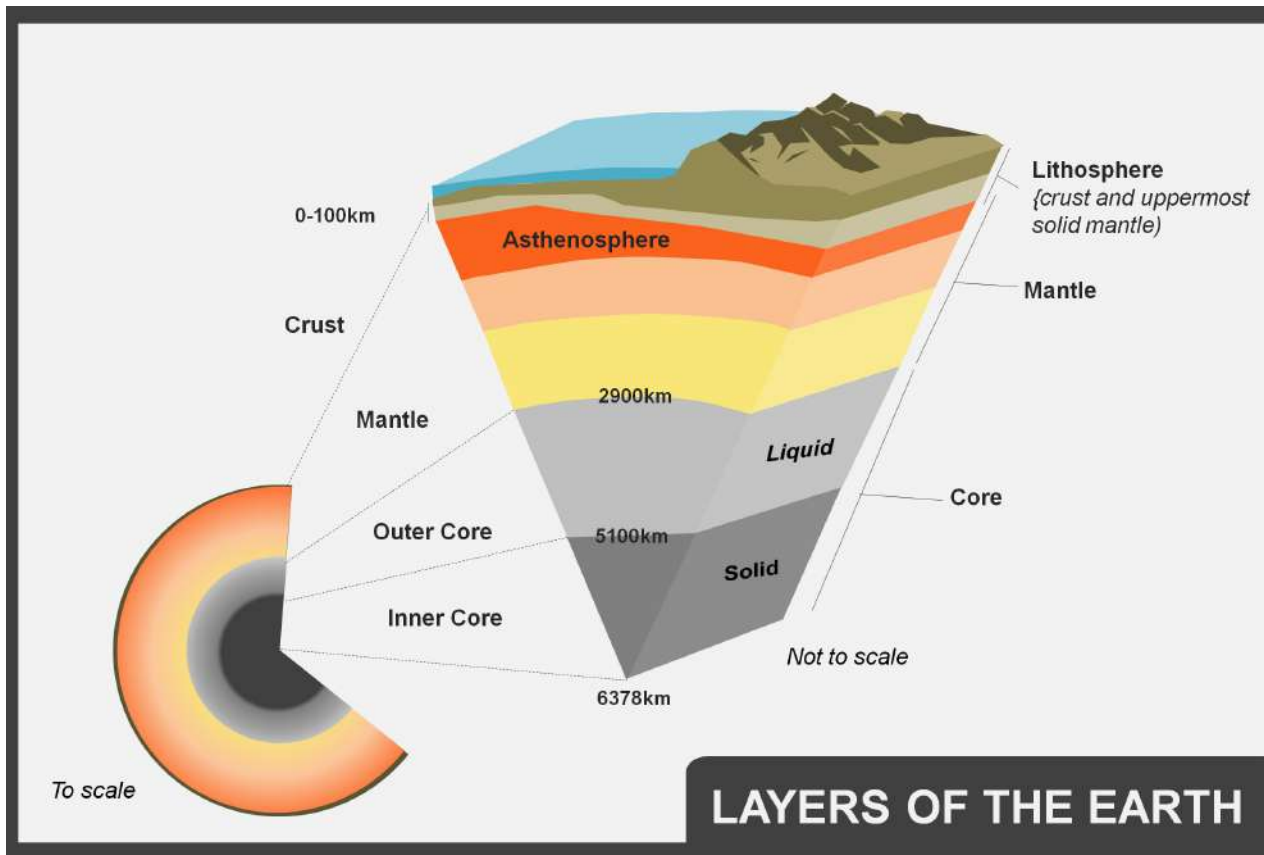
Students have had prior exposure to most of these terms in Junior High School science. Write their own definitions on the board. This would serve as a good check of the students' prior knowledge and their misconceptions about the presented terms/ words.

MOTIVATION (10 MINS)

1. Hold up a globe or a basketball and explain to students that the Earth is shaped like a ball. Have the students write and sketch a description of what they think the inside of the Earth looks like. Encourage students to put in as much detail as they can. List student responses on the board and leave them up and refer to them throughout the lesson.

INSTRUCTION /DELIVERY (25 MINS)

Give a demonstration/lecture/simulation Lecture proper (Outline)



Cutaway views showing the internal structure of the Earth

How scientists look into earth's interior

1. Briefly discuss how seismic waves (P-and S-waves) behave as they travel through the Earth

Earth's layered structure

1. Earth consists of three concentric layers: the Crust, Mantle, and Core.
 - A. Discuss the composition of each layer;
 - B. Describe how temperature, pressure, and density change as you travel deeper down the Earth
 - C. Contrast continental crust and oceanic crust
Discuss the crust-mantle boundary (Moho) and how it was discovered
Introduce the idea of the lithosphere being broken into smaller pieces called plates which move about on top of the asthenosphere
 - D. Describe the layering within the mantle
 - E. Discuss what the inner core is made up of and why it is solid. Contrast inner and outer core

ENRICHMENT (45 MINS)

Egg-cellent Earth activity: using hard-boiled egg as a model of Earth's structure

1. Have students form small groups (of 3 or 4) and provide them with hard-boiled egg, paper plate, plastic knife, and marker. Explain to students that they will be using the egg as a model to represent the earth's structures. Instruct the students to describe the eggshell and identify what part of the earth the eggshell represents.
2. Ask students to crack the eggshell by gently rolling the egg against the table. Have them describe the appearance of the eggshell and identify the part of the earth the broken eggshell represents.
3. Ask students to carefully cut the egg in half. Students should mark the center of the yolk with a dot using a marker. They should identify which parts of the Earth interior are modelled by the cut egg (shell, white, yolk, dot), and describe how the model demonstrates characteristics of these layers (solid, liquid, etc.). Each student should make an annotated sketch with actual parts of the egg labeled on the left side and the layers of the Earth they represent on the other side.
4. When students are done with their task, display (project a transparency of) a cross section of the Earth's layers to compare with the egg model.
5. Lead a brief discussion with students having them identify the similarities and differences between the egg model and the corresponding layers of the Earth.

Teacher Tips:

- In this activity, the shell represents the crust, the eggwhite represents the mantle, and the yolk represents the core, the dot represents inner core.
- It is recommended that the students work in groups of 3-4 for this activity. Each group will be given one hard-boiled egg each prepared by the teacher. To facilitate cleanup, have the students use the paper plate as placemat.

EVALUATION (20 MINS)

1. Challenge students to devise alternative analogies for the internal structure of the Earth. In a small group, the students will discuss the limitations and strengths of each of these and write their observations in table form. They should be able to make an annotated diagram for each of their models.

Teacher Tip:

Students' answers may vary. They may give examples like, "the earth is like an onion, it is composed of several layers." Or "The Earth is like an apple with the skin resembling the crust, ...". The goal is to encourage students to identify the differences and similarities of their model and the corresponding earth layer.

EVALUATION				
	4 (EXCEEDS EXPECTATIONS)	3 (MEETS EXPECTATIONS)	2 (NEEDS IMPROVEMENT)	1 (NOT VISIBLE)
Identify similarities and differences between the egg model and corresponding layers of the Earth				
Identifies several analogies to illustrate internal structure of the Earth.				

Lesson 6: Minerals and Rocks

Content Standard

The learners demonstrate an understanding of the three main categories of rocks.

Learning Competency

The learners shall be able to make a plan that the community may use to conserve and protect its resources for future generations. The learners shall be able to identify common rock-forming minerals using their physical and chemical properties **(S11/12ES-Ia-9)**.

Specific Learning Outcomes

At the end of the lesson, the learners will be able to

1. Demonstrate understanding about physical and chemical properties of minerals
2. Identify some common rock-forming minerals
3. Classify minerals based on chemical affinity

LESSON OUTLINE

Introduction	Communicate Learning Objectives	3
Motivation	Review stock knowledge about minerals	5
Instruction	Discussion	22
Practice	Activity on Mineral Identification	15

Materials

- (1) Mineral Decision Tree, Mineral Identification Charts

Resources

- (1) Laboratory Manual for Physical Geology – Mineral Identification. Retrieved from https://gln.dcccd.edu/Geology_Demo/content/LAB03/LAB_Man_03.pdf
- (2) Mindat.org. (n.d.). Definition of rock-forming minerals. Retrieved from http://www.mindat.org/glossary/rock-forming_mineral
- (3) Monroe, J. S., Wicaner, R. & Hazlett, R. (2007). Physical Geology Exploring the Earth (6th ed., pp. 80-90). Pacific Grove, CA: Brooks/Cole.
- (4) Prestidge, D. (2012, May). Earth: Portrait of a planet (Chapter 5 - Patterns in Nature: Minerals). Retrieved from <http://www.slideshare.net/davidprestidge/earth-lecture-slide-chapter-five>
- (5) How to identify mineral. Retrieved from <http://www.instructables.com/id/How-to-identify-a-Mineral/step3/Hardness/>

INTRODUCTION (3 MINS)

Communicate learning objectives

1. Introduce the following learning objectives using the suggested protocols (Verbatim, Own Words, Read-aloud)
 - A. I can identify and describe the different properties of minerals.
 - B. I can group the minerals based on chemical composition.
 - C. I can identify several common rock-forming minerals.
2. Enumerate the five important properties which define a mineral.
 - A. Mineral — a naturally occurring (not man-made or machine generated), inorganic (not a by-product of living things) solid with an orderly crystalline structure and a definite chemical composition
 - B. Minerals are the basic building blocks of rocks.

Teacher Tip:

Cite examples of minerals used in our daily lives: halite (salt) for cooking, graphite (pencil) for writing, diamond and gold as jewelry, etc.

MOTIVATION (5 MINS)

Questions for the learners

1. Do you consider water a mineral?
Answer: No. It is not solid and crystalline.
2. How about snowflake, or tube ice? Are these minerals?
Answer: Tube ice is not a mineral, because it is not naturally occurring. But a snowflake possesses all the properties under the definition of a mineral.

INSTRUCTION DELIVERY (22 MINS)

MINERAL PROPERTIES

1. Use table salt or halite to demonstrate the different mineral properties.
2. Tabulate the answers on the board using the template below.

Mineral Name	Halite (table salt)
Chemical composition	NaCl
Luster	Non-metallic – vitreous; transparent to translucent
Hardness	Soft (2-2.5)
Color	White
Streak	White
Crystal Form / Habit	Cubic
Cleavage	Perfect cubic
Specific Gravity	Light (2.2)
Other Properties	Salty taste; very soluble; produces reddish spark in flame

There are several different mineral properties which must be identified and defined.

1. **Luster** – it is the quality and intensity of reflected light exhibited by the mineral
 - a. Metallic – generally opaque and exhibit a resplendent shine similar to a polished metal
 - b. Non-metallic – vitreous (glassy), adamantine (brilliant/diamond-like), resinous, silky, pearly, dull (earthy), greasy, among others.
2. **Hardness** – it is a measure of the resistance of a mineral (not specifically surface) to abrasion.
 - a. Introduce students to the use of a hardness scale designed by German geologist/mineralogist Friedrich Mohs in 1812 (Mohs Scale of Hardness).
 - b. The Mohs Scale of Hardness measures the scratch resistance of various minerals from a scale of 1 to 10, based on the ability of a harder material/mineral to scratch a softer one.
 - c. Pros of the Mohs scale:
 - i. The test is easy.
 - ii. The test can be done anywhere, anytime, as long as there is sufficient light to see scratches.
 - iii. The test is convenient for field geologists with scratch kits who want to make a rough identification of minerals outside the lab.

d. Cons of the Mohs scale:

- i. The Scale is qualitative, not quantitative.
- ii. The test cannot be used to accurately test the hardness of industrial materials.

Mohs scale of Hardness



<https://s-media-cache-ak0.pinimg.com/564x/df/fa/6c/dffa6c9f697edd062da51204c6a03211.jpg>

3. Crystal Form/Habit

The external shape of a crystal or groups of crystals is displayed / observed as these crystals grow in open spaces. The form reflects the supposedly internal structure (of atoms and ions) of the crystal (mineral). It is the natural shape of the mineral before the development of any cleavage or fracture. Examples include prismatic, tabular, bladed, platy, reniform and equant. A mineral that do not have a crystal structure is described as amorphous.

4. Color and streak

- a. A lot of minerals can exhibit same or similar colors. Individual minerals can also display a variety of colors resulting from impurities and also from some geologic processes like weathering.
 - b. Examples of coloring: quartz can be pink (rose quartz), purple (amethyst), orange (citrine), white (colorless quartz) etc.
 - c. Streak, on the other hand, is the mineral's color in powdered form. It is inherent in almost every mineral, and is a more diagnostic property compared to color. Note that the color of a mineral can be different from its streak.
 - d. Examples of streak: pyrite (FeS_2) exhibits gold color but has a black or dark gray streak.
 - e. The crystal's form also defines the relative growth of the crystal in three dimensions, which include the crystal's length, width and height.
- i. Activity: Show the pictures to the learners and try to identify the crystal forms / habits. Provide more pictures if needed



Crystal form / habit. Source: <http://www.slideshare.net/davidprestidge/earth-lecture-slide-chapter-five> page 46 of 74 (8/30/2015)

Answer: Left picture: blocky/cubic or equant (it has equal growth rate in three dimensions). Middle picture: bladed habit (it resembles a blade, with varied growth rates in 3 dimensions). Right picture: needle-like habit (rapid growth of crystals in one dimension while slow in other dimensions).



Color vs streak of a hematite (Fe_2O_3). Source: <http://www.instructables.com/id/How-to-identify-a-Mineral/step6/Streak/> (8/30/2015)

5. **Cleavage** – the property of some minerals to break along specific planes of weakness to form smooth, flat surfaces
 - a. These planes exist because the bonding of atoms making up the mineral happens to be weak in those areas.
 - b. When minerals break evenly in more than one direction, cleavage is described by the number of cleavage directions, the angle(s) at which they meet, and the quality of cleavage (e.g. cleavage in 2 directions at 90°).
 - c. Cleavage is different from habit; the two are distinct, unrelated properties. Although both are dictated by crystal structure, crystal habit forms as the mineral is growing, relying on how the individual atoms in the crystal come together. Cleavage, meanwhile, is the weak plane that developed after the crystal is formed.
6. **Specific Gravity** – the ratio of the density of the mineral and the density of water
 - a. This parameter indicates how many times more the mineral weighs compared to an equal amount of water (SG 1).
 - b. For example, a bucket of silver (SG 10) would weigh ten times more than a bucket of water.
7. **Others** – magnetism, odor, taste, tenacity, reaction to acid, etc. For example, magnetite is strongly magnetic; sulfur has distinctive smell; halite is salty; calcite fizzes with acid as with dolomite but in powdered form; etc.

MINERAL GROUPS

1. Ask the students if they think minerals can be grouped together, and the basis for such groupings.

Most likely answer: on the basis of physical properties.

Response: Although physical properties are useful for mineral identification, some minerals may exhibit a wide range of properties.

2. Minerals, like many other things, can also be categorized.

The most stable and least ambiguous basis for classification of minerals is based on their chemical compositions.

Element	Element + SiO ₄	Element + O ₂	Element + SO ₄	Element + S ₂	Element + CO ₃	Element + Halogens
Native	Silicate	Oxide	Sulfate	Sulfide	Carbonate	Halide
Gold	Quartz	Hematite	Gypsum	Pyrite	Calcite	Chlorine
Bismuth	Olivine	Magnetite	Barite	Galena	Dolomite	Fluorine
Diamond	Talc	Chromite	Anhydrite	Bornite	Malachite	Halite

The elements listed below comprise almost 99% of the minerals making up the Earth's crust.

Element	Symbol	% by weight of Earth's crust	% atoms
Oxygen	O	46.6	62.6
Silicon	Si	27.7	21.2
Aluminum	Al	8.1	6.5
Iron	Fe	5.0	1.9
Calcium	Ca	3.6	1.9
Sodium	Na	2.8	2.6
Potassium	K	2.6	1.4
Magnesium	Mg	2.1	1.8
All other elements		1.4	<0.1

<i>Important Rock-Forming Minerals</i>	
Mineral	Primary Occurrence
Ferromagnesian silicates	
Olivine	Igneous, metamorphic rocks
Pyroxene group	
Augite most common	Igneous, metamorphic rocks
Amphibole group	
Hornblende most common	Igneous, metamorphic rocks
Biotite	All rock types
Nonferromagnesian silicates	
Quartz	All rock types
Potassium feldspar group	
Orthoclase, microcline	All rock types
Plagioclase feldspar group	All rock types
Muscovite	All rock types
Clay mineral group	Soils, sedimentary rocks, some metamorphic rocks
Carbonates	
Calcite	Sedimentary rocks
Dolomite	Sedimentary rocks
Sulfates	
Anhydrite	Sedimentary rocks
Gypsum	Sedimentary rocks
Halides	
Halite	Sedimentary rocks

Source: Monroe, J. S., et al, *Physical Geology Exploring the Earth*, 6th ed., 2007, p90

1. **Silicates** – minerals containing the two most abundant elements in the Earth's crust, namely, silicon and oxygen.
 - a. When linked together, these two elements form the silicon oxygen tetrahedron - the fundamental building block of silicate minerals.
 - b. Over 90% of rock-forming minerals belong to this group.
2. **Oxides** – minerals composed of oxygen anion (O_2^-) combined with one or more metal ions
3. **Sulfates** – minerals containing sulfur and oxygen in the form of the $(SO_4)^-$ anion
4. **Sulfides** – minerals containing sulfur and a metal; some sulfides are sources of economically important metals such as copper, lead, and zinc.
5. **Carbonates** – minerals containing the carbonate $(CO_3)_2^-$ anion combined with other elements
6. **Native Elements** – minerals that form as individual elements
 - a. **Metals and Intermetals** – minerals with high thermal and electrical conductivity, typically with metallic luster, low hardness (gold, lead)
 - b. **Semi-metals** – minerals that are more fragile than metals and have lower conductivity (arsenic, bismuth)
 - c. **Nonmetals** – nonconductive (sulfur, diamond)
7. **Halides** – minerals containing halogen elements combined with one or more metals

Note

1. Rock-forming minerals make up large masses of rocks, such as igneous, sedimentary, or metamorphic rocks. Rock-forming minerals are essential for the classification of rocks, whereas accessory minerals can be ignored in this endeavor.
2. Almost 85% of the atoms in the earth's crust are oxygen and silicon. Therefore, the most common and abundant rock-forming minerals are silicates. Some carbonates are also abundant. The most common rock-forming minerals are tabulated on the right.

PRACTICE (15 MINUTES)

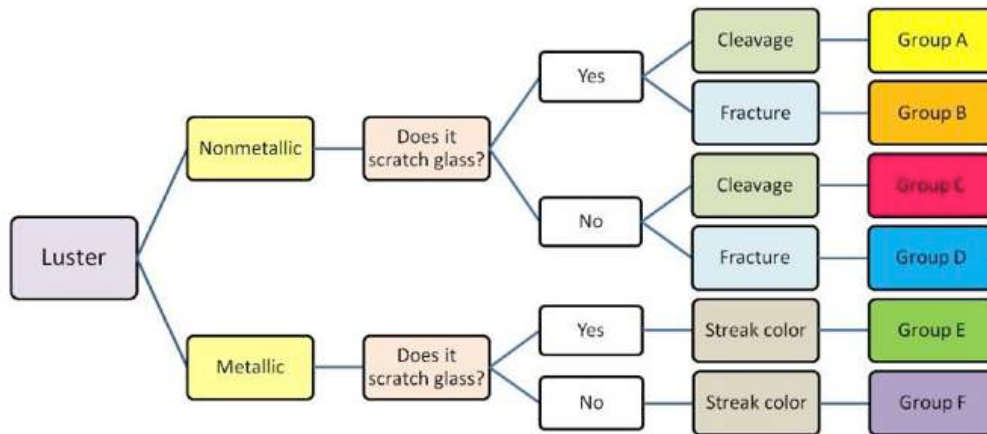
Activity: How to identify minerals.

Present the Mineral Decision Tree to the class, as a visual guide in explaining the methods used by geologists to identify minerals.. Source: https://gln.dcccd.edu/Geology_Demo/content/LAB03/LAB_Man_03.pdf, pp.24-30

1. Show a mineral sample (or picture) that the class will try to identify.
2. Use the diagram below to narrow down the mineral choices into groups A to F. Then refer to the provided mineral chart for the list of possible minerals.
3. Test the other properties provided in the chart to identify the mineral.

Ask the students in groups to identify one or more minerals. Or ask individual students to come to the front to demonstrate the process of identification to the class.

- Provide all students with a copy of the mineral charts.
- Provide a mineral sample (can be an actual mineral, or a picture). You may also begin by supplying some properties needed to identify the mineral.



ENRICHMENT

- Homework, to be submitted next meeting: List five minerals and their common uses. Identify the specific property/properties that makes the mineral suitable for those uses. For example, graphite, having a black streak and hardness of 1-2, is used in pencils due to its ability to leave marks on paper and other objects.

EVALUATION

1. Summarize the different characteristics that define a mineral.

Answer: inorganic, naturally occurring, crystalline, solid and must have a consistent chemical composition.

2. Which among the following mineral groups, if any, contain silicon: halides, carbonates or sulfides? Explain.

Answer: None. The identified mineral groups are nonsilicates.

3. Which is more abundant in the Earth's crust: silicates or all the other mineral groups combined? Explain.

Answer: Silicates. Silicon and oxygen are the main components of silicates and these are the two most abundant elements in the Earth's crust.

4. An unknown opaque mineral has a black streak and has a density of 18g/cm³. Is the mineral metallic or non-metallic?

Answer: The mineral is more likely to be metallic because it is opaque and metallic minerals are usually heavy and with dark streaks

5. How does streak differ from color, and why is it more reliable for rock identification?

Answer: Streak is the color of a mineral in powdered form. It is more reliable because it is inherent to most minerals. Color is not reliable because a mineral can be formed with varieties of color, an effect of impurities and weathering.

6. Differentiate between *habit* and a *cleavage plane*.

Answer: Habit is the external shape of a crystal that is developed during the formation of the mineral. A cleavage plane is a plane of weakness that may develop after the crystal formation.

7. Is it possible for a mineral to have a prismatic habit without having any cleavage? Why or why not? If yes, give an example.

Answer: Yes, the prismatic habit is simultaneously developed while the mineral is growing. During the process, there is no repetitive plane of weakness being created which makes the mineral break only by fracturing. An example of this scenario is quartz.

8. Define "rock-forming mineral," and give three examples.

Answer: A rock-forming mineral is a mineral that is common and abundant in the Earth's crust; one making up large masses of rock.

Lesson 7: Minerals and Rocks

Content Standard

The learners demonstrate an understanding of the three main categories of rocks, and the origin and environment of formation of common minerals and rocks.

Learning Competency

The learners shall be able to make a plan that the community may use to conserve and protect its resources for future generations. The learners will be able to classify rocks into igneous, sedimentary and metamorphic **(S11/12ES-Ib-10)**.

Specific Learning Outcomes

At the end of the lesson, the learners will be able to

1. Classify and describe the three basic rock types;
2. Establish relationships between rock types and the origin and environment of deposition/formation;
3. Understand the different geologic processes involved in rock formation

LESSON OUTLINE

Introduction	Communicating Learning Objectives	3
Motivation	Rock Types and Rock Cycle Videos	5
Instruction	Rock Classification and Rock Cycle	37
Practice	Group activity on concept mapping of the different rock types	15

Materials

For the motivation section: slide projector; For the practice section: flash cards, manila paper, marker pen, adhesive tape

Resources

- (1) The Rock Cycle by Kelly Dunham (Accessed 09/20/2015)<https://www.youtube.com/watch?v=9lyCYXXIHT0>
- (2) The Rock Cycle by Annenberg Learner (Accessed 09/18/2015)<http://www.learner.org/interactives/rockcycle/diagram.html>
- (3) Tarbuck, Lutgens, and Tasa. Earth An Introduction to Physical Geology 11thed, 2014
- (4) Rock flowchart by Michael Sammartano (Accessed 09/18/2015)
- (5) Blank template: <http://www.hmxearthscience.com/Sammartano/Rocks%20Flow%20Chart.pdf> filled up template by combining data from the following videos:
 - i. Introduction to Igneous Rocks <https://www.youtube.com/watch?v=aCnAF1Opt8M>
 - ii. Introduction to Sedimentary Rocks <https://www.youtube.com/watch?v=Etu9BWbuDIY>
 - iii. Metamorphic Rocks Video <https://www.youtube.com/watch?v=1oQ1J0w3x0o>
- (6) Photos for motivation section:
- (7) <https://1dragonwriter.wordpress.com/2011/05/17/edinburgh-may-17/> (for Edinburgh castle photo 02/25/2016)
- (8) <http://www.public-domain-image.com/> (02/25/2016)

INTRODUCTION (3 MINS)

Communicate learning objectives

Introduce the following learning objectives using the suggested protocols (Verbatim, Own Words, Read-aloud)

1. I can classify and describe the three basic rock types;
2. I can explain how and what type of environment each of these rock types are formed;
3. I can explain how rocks are transformed from one rock type to another through the rock cycle;
4. I can identify and describe the different geologic processes that operate within the rock cycle.

Review

Rocks are aggregate of minerals. It can be composed of single mineral (e.g. Quartzite, a metamorphic rock composed predominantly of Quartz) or more commonly, as an aggregate of two or more minerals. A mineral name can be used as a rock name (e.g. Gypsum Rock which is composed predominantly of the mineral Gypsum (CaSO_4)).

MOTIVATION (5 MINS)

Show slide photographs of several rock formations and give brief descriptions about them. The teacher can choose from the folder of photos that comes together with this TG.

INSTRUCTIONAL DELIVERY (37 MINS)

Rock Classifications

Rocks are classified on the basis of the mode of formation. The three rock types are igneous, sedimentary and metamorphic rocks.

1. **Igneous rocks** - rocks that are formed from the solidification of molten rock material (magma or lava). Molten rock material can solidify below the surface of the earth (plutonic igneous rocks) or at the surface of the Earth (volcanic igneous rocks). Minerals are formed during the crystallization of the magma. Note that the rate of cooling is one of the most important factors that control crystal size and the texture of the rock in general.

Question: Differentiate magma and lava.

Magma is a molten rock material beneath the surface of the earth. Lava is molten rock material extruded to the surface of the earth through volcanic or fissure eruptions.

Question: Describe plutonic or intrusive rocks and define the process of formation, the texture and give examples.

- from solidified magma underneath the earth
- gradual lowering of the temperature gradient at depth towards the surface would cause slow cooling/crystallization
- Phaneritic texture
- Examples: granite, diorite, gabbro

Question: Describe volcanic or extrusive rocks and define the process of formation, the texture and give examples.

- from solidified lava at or near the surface of the earth
- fast rate of cooling/crystallization due to huge variance in the temperature between Earth's surface and underneath
- common textures: aphanitic, porphyritic and vesicular
- examples: rhyolite, andesite, basalt
- pyroclastic rocks: fragmental rocks usually associated with violent or explosive type of eruption. Examples tuff and pyroclastic flow deposits (ignimbrite)

Igneous rocks are also classified according to silica content: felsic, intermediate, mafic and ultramafic.

- felsic: also called granitic; >65% silica, generally light-colored
- intermediate: also called andesitic; 55-65% silica; generally medium colored (medium gray)
- mafic: also called basaltic; 45-55% silica; generally dark colored
- ultramafic: <45% silica; generally very dark colored; composed mainly of olivine and pyroxene which are the major constituents of the upper mantle

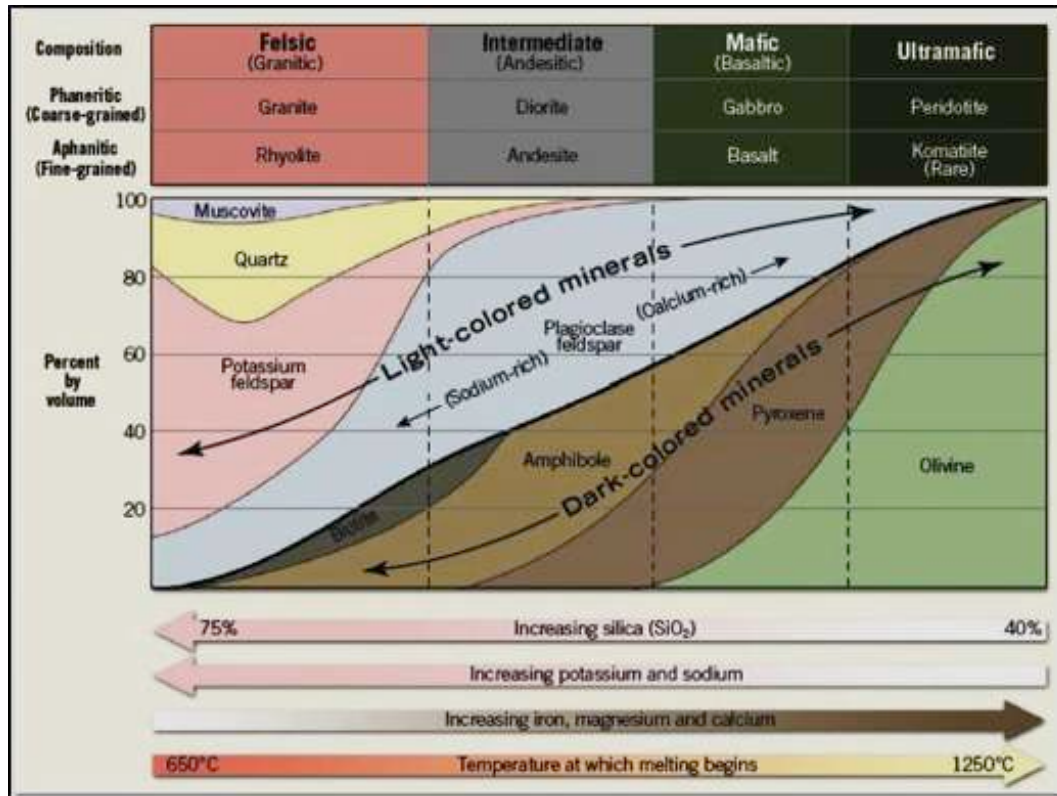
Slow cooling forms large interlocking crystals, a texture called phaneritic.

Fast cooling does not promote the formation of large crystals.

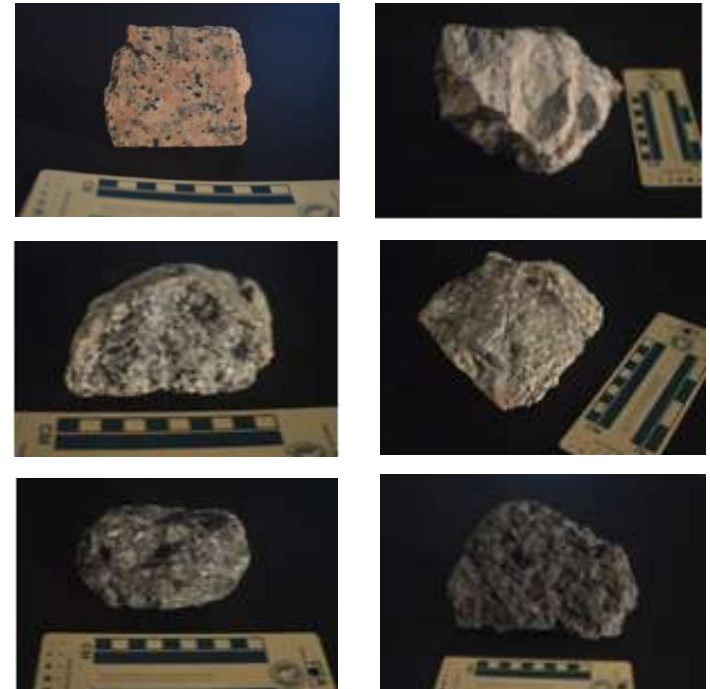
Aphanitic texture: fine-grained texture; minerals not visible to the naked eye; relatively fast rates of cooling/solidification prevented the formation of large crystals.

Porphyritic texture: formed through two stages of crystallization: magma partly cooled below the surface of the Earth, giving time for the large crystals to grow (phenocrysts) before it is extruded to the surface forming the fine-grained groundmass.

Vesicular texture: voids created by rapid cooling which causes air bubbles to be trapped inside.



Photographs of common intrusive rocks with their extrusive counterparts



1. The teacher has the option of changing the photographs
2. **Granite** on the top left with phaneritic texture and **rhyolite** on the top right with aphanitic and vesicular texture.
3. **Diorite** on middle left with phaneritic texture vs **andesite** on middle right with aphanitic texture. Same composition but different textures
4. **Gabbro** on bottom left with phaneritic texture vs **basalt** on bottom right with aphanitic texture. Although the crystals in the gabbro may not be large, they are still visible.
5. Temperature and pressure at the Earth's surface are low, allowing sedimentary processes to happen
6. Sediment: solid fragments of organic or inorganic materials from weathered and eroded pre-existing rocks and living

2. **Sedimentary rocks**- These are rocks that formed through the accumulation, compaction, and cementation of **sediments**. They generally form at surface or near surface conditions.
- Sedimentary processes at or near the surface of the Earth include: weathering of rocks, sediment transport and deposition, compaction and cementation
 - Factors in sedimentary processes: weathering and transport agents (water, wind ice)
 - Common sedimentary features: strata and fossils
 - Strata: >1cm is called bedding and anything less is called lamination; layering is the result of a change in grain size and composition; each layer represents a distinct period of deposition.
 - Fossils: remains and traces of plants and animals that are preserved in rocks

Non-clastic / Chemical/Biochemical – derived from sediments that precipitated from concentrated solutions (e.g. seawater) or from the accumulation of biologic or organic material (e.g. shells, plant material). They are further classified on the basis of chemical composition.

Clastic/terrigenous - form from the accumulation and lithification of sediments derived from the breakdown of pre-existing rocks. They are further classified according to dominant grain size.



1. **Conglomerate** on top left relatively large and rounded clasts as compared to the angular clasts of the **breccia** on top right.
2. **Sandstone** middle left with visible grains and prominent layering and **claystone** on middle right with several embedded fossils.
3. Non-clastic sedimentary rocks **limestone** on bottom left and **coquina** on bottom right.

Source:

Sandstone [https://upload.wikimedia.org/wikipedia/commons/9/9b/Ferruginous_Sandstone_\(banded\)_label.JPG](https://upload.wikimedia.org/wikipedia/commons/9/9b/Ferruginous_Sandstone_(banded)_label.JPG)

3. **Metamorphic rocks** - rocks that form from the transformation of pre-existing rocks (igneous, sedimentary, or metamorphic rocks) through the process of metamorphism. Metamorphism can involve changes in the physical and chemical properties of rocks in response to heat, pressure, and chemically active fluids. They are commonly formed underneath the earth through metamorphism

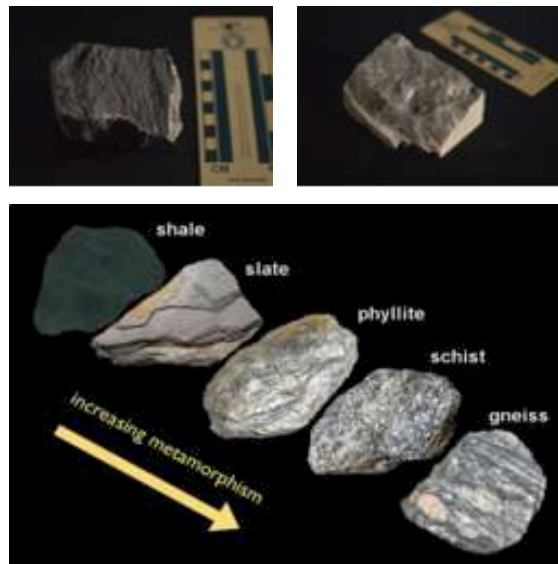
Contact metamorphism

- Heat as the main factor: occurs when a pre-existing rocks get in contact with a heat source (**magma**)
- Occurs on a relatively small scale: around the vicinity of intruding magma
- Creates **non-foliated** metamorphic rocks (e.g. hornfels)

Regional metamorphism

- Pressure as main factor: occurs in areas that have undergone **deformation** during orogenic event resulting in mountain belts
- Occurs in a regional/large scale
- Creates **foliated** metamorphic rocks such as schist and gneiss
- Non-foliated rocks like marble also form thru regional metamorphism, where pressure is not intense, far from the main geologic event

TEXTURE	GRAIN SIZE	COMPOSITION	TYPE OF METAMORPHISM	COMMENTS	ROCK NAME	MAP SYMBOL
FOLIATED MINERAL ALIGNMENT BANDING	Fine	MICA QUARTZ FELDSPAR AMPHIBOLE GARNET PYROXENE	Regional (Heat and pressure increases)	Low-grade metamorphism of shale	Slate	
	Fine to medium			Foliation surfaces shiny from microscopic mica crystals	Phyllite	
	Medium to coarse			Platy mica crystals visible from metamorphism of clay or feldspars	Schist	
				High-grade metamorphism; mineral types segregated into bands	Gneiss	
NONFOLIATED	Fine	Carbon	Regional	Metamorphism of bituminous coal	Anthracite coal	
	Fine	Various minerals	Contact (heat)	Various rocks changed by heat from nearby magma/lava	Hornfels	
	Fine to coarse	Quartz	Regional or contact	Metamorphism of quartz sandstone	Quartzite	
		Calcite and/or dolomite		Metamorphism of limestone or dolostone	Marble	
	Coarse	Various minerals		Pebbles may be distorted or stretched	Metaconglomerate	



Non-foliated rocks: **Hornfels** (left), a fine-grained rock that forms through contact metamorphism of non-carbonate rocks. **Marble** (right) is formed through the metamorphism of limestone or dolostone; traces of fossils/remains are obscured by recrystallization.

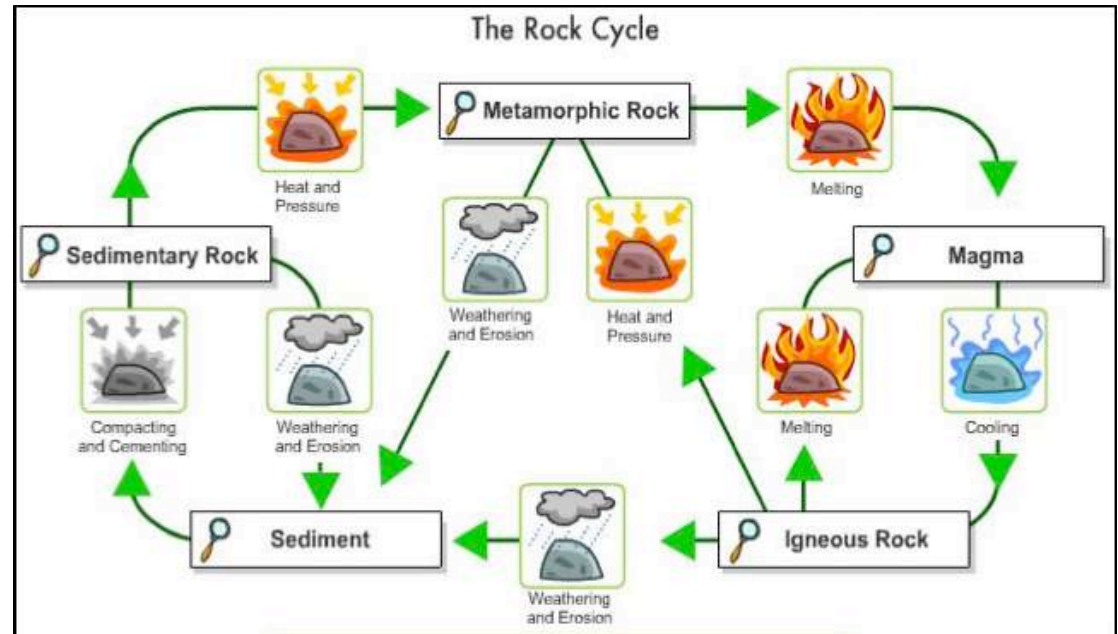
Foliated rocks (bottom) from shale as precursor rock. **Metamorphic grade** increases (from slate to gneiss) as pressure increases.

Source: http://2.bp.blogspot.com/-K5WWnSwIFd0/VquIU8_PM2I/AAAAAAAAAHrY/0Lui_DqxK5A/s1600/The%2Bformation%2Bof%2BFoliated%2BMetamorphic%2BRock-geology%2Bin.jpg

The Rock Cycle

- Show a quick video about the rock cycle (<https://www.youtube.com/watch?v=9lyCYXXIHT0>)
- The rock cycle illustrates how geologic processes occurring both at the surface and underneath the Earth's surface can change a rock from one type to another.

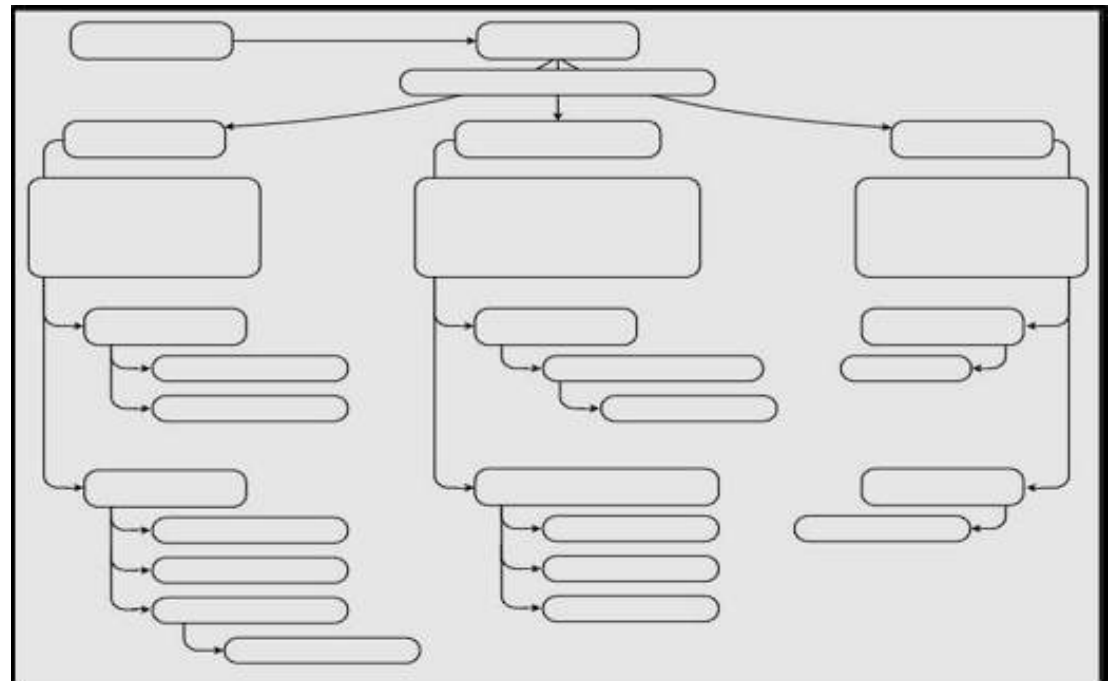
Source: <https://www.thinglink.com/scene/359446759849590786>



PRACTICE (15 MINS)

Concept Mapping of the different rock types

Prepare in a Manila paper a flowchart template similar as the one on the right and post it in the board. Call students to fill up the flowchart by taping the flash cards in their proper location.



Each flash card should contain the following words/phrases

pressure	biological matter	lava cools quickly
clastic	maybe vesticular	compacted sediments
extrusive	classified by size	contains air bubbles
rocks	large crystals form	small or no crystals forms
heat	evaporites	magma cools slowly
contact	metamorphic	classified on how they are formed
intrusive	building blocks of	precipitates
mineral	non-clastic	sedimentary
igneous	regional	generally forms from the compaction and cementation of sediments
forms from cooling and solidification of lava or magma	rocks change due to temperature and/or pressure change	

ENRICHMENT

An assessment homework can be given and to be submitted next meeting. Each student will do research on 3 rocks (one for each rock type). Included in the discussion are the following: history of formation, common environment of formation, common textures, common use of the rock and the localities in the Philippines where you can find them.

EVALUATION

1. How does a vesicular texture in a volcanic rock develop?

Answer: As magma rises up to the surface, it is subjected to decreasing pressure, allowing dissolved gases to come out of the solution forming gas bubbles. When the magma reaches the surface (as lava) and cools, the rock solidifies around the gas bubbles. The bubbles are then preserved as holes or vesicles. Also, the texture can also be formed thru the rapid escape of gases.

2. Explain why the vesicular texture is not associated with peridotites.

Answer: Peridotites are intrusive rocks formed beneath the earth's surface and the high pressure conditions prevent gases from forming and escaping.

3. How do clastic rocks differ from non-clastic rocks in terms of process of formation?

Answer: Clastic rocks form from rock fragments transported away from their source by wind, water, gravity or ice rather than by chemical processes such as precipitation or evaporation.

4. Explain how the physical features of sediments change during transport.

Answer: The farther the sediment is transported, the longer the transport takes, and the smaller, more rounded and smoother the sediment becomes.

5. Differentiate between a foliated and non-foliated rock.

Answer: Foliated rocks has a texture in which the mineral grains are arranged in bands or grains, which is absent in a non-foliated rock.

6. What do butterflies and metamorphic rocks have in common?

Answer: Butterflies and metamorphic rocks both undergo change from an earlier form (caterpillar for butterfly, parent rock for metamorphic rock) to a new one.

7. Heat is a major agent in metamorphism and igneous rock formation, but not in sedimentary rocks. Why?

Answer: Sedimentary processes occur in surface conditions - low temperature and pressure conditions.

8. Does every rock go through the complete rock cycle, i.e. changing from igneous to sedimentary rock to metamorphic then back to igneous rocks? Explain.

Answer: No. Rocks can change into any type of rock or even reform as the same kind of rock for several cycles.

Lesson 8: Exogenic Processes

Content Standard

The learners will be able to develop and demonstrate an understanding of geologic processes that occur on the surface of the Earth such as weathering, erosion, mass wasting, and sedimentation.

Learning Competency

The learners shall be able to describe how rocks undergo weathering
(S11/12ES-Ib-11)

Specific Learning Outcomes

At the end of the lesson, the learners will be able to

1. Define weathering and distinguish between the two main types of weathering
2. Identify the factors that affect the rate of weathering

LESSON OUTLINE

Introduction	Presentation of objectives and terms	2
Motivation	Bell ringer question	3
Instruction	Lecture proper and discussion	30
Enrichment	Laboratory activity	15
Evaluation	Think Pair Share	10

Materials

Nail (new and rusted), antacids (sodium bicarbonate), clear plastic cups, mortar and pestle, stopwatch

Resources

This lesson is adapted from activities and information at the following sites:

- (1) Breaking it down. <http://www-tc.pbs.org/wnet/nature/files/2008/12/breaking-it-down.pdf>. Accessed 9/22/2015
- (2) Alka-seltzer lab. http://newyorkscienceteacher.com/sci/files/user-submitted/alka-seltzer_lab.pdf. Accessed 9/22/2015

Textbook sources:

- (1) Tarbuck, E.J., F.K. Lutgens, and D. Tasa. 2014. Earth An Introduction to Physical Geology. Eleventh Edition. Prentice Hall.
- (2) Monroe, J.S., Wicander, R., and Hazlett, R. 2007. Physical Geology: Exploring the Earth 6th edition. Thomson Brookes/Cole.

INTRODUCTION (2 MINS)

1. Introduce the following learning objectives and important terms
 - a. I can define weathering and distinguish between the two main types of weathering
 - b. I can identify the factors that affect the rate of weathering
2. Introduce the list of key terms that learners will encounter.
 - a. Weathering
 - b. Mechanical weathering
 - c. Abrasion
 - d. Chemical weathering
 - e. Hydrolysis
 - f. Carbonation
 - g. Oxidation
 - h. Frost wedging
3. Copy the key terms on the board. Have the students write the definitions in their own words.

Teacher Tip:

Students have had prior exposure to most of these terms in pre SHS science. Have students revise their definitions after the lecture.

MOTIVATION (3 MINS)

Show students a sample of a large rock. Ask the students, "Can you name any natural cause or process that could possibly break the rock into smaller pieces?" An alternative question that could also invoke their prior knowledge of the early Earth would be: "If the early Earth's crust was mainly composed of rocks, why do we have layers of soil on the surface now? Where did these soils come from?" Write their responses on the board and briefly discuss with the class.

Teacher Tip:

Students' answers may vary. Some typical answers may be water, wind, physical impact, waves, temperature changes, etc.

INSTRUCTION /DELIVERY/PRACTICE (30 MINS)

Give a demonstration/lecture/simulation

Lecture proper

1. Define weathering and name the two main categories of weathering processes (physical and chemical). Describe how rocks disintegrate through weathering processes. Explain that weathering usually occurs in situ (in place).
2. Discuss the processes by which mechanical weathering takes place. To demonstrate physical weathering, place an effervescent antacid tablet on the table and break or crush it with a spoon. Explain to students that this shows physical weathering as the tablet is broken into smaller pieces without altering its composition. Another example is tearing a piece of paper. Discuss the following processes that lead to the mechanical disintegration of rocks:
 - a. **Frost wedging**- when water gets inside the joints, alternate freezing and thawing episodes pry the rock apart.
 - b. **Salt crystal growth**- force exerted by salt crystal that formed as water evaporates from pore spaces or cracks in rocks can cause the rock to fall apart
 - c. **Abrasion** – wearing away of rocks by constant collision of loose particles
 - d. **Biological activity** – plants and animals as agents of mechanical weathering
3. Describe the processes that contribute to chemical weathering. Teacher may demonstrate chemical weathering by simply dissolving an antacid in water or burning a piece of paper. Teacher may also have students examine and compare a new nail and a severely rusted nail. Show students how the rusted nail can be crumbled by bare hand (Note: one should obtain a thoroughly rusted nail to use for this demonstration). Ask students what they can infer from the reddish coloration seen on surface of some rocks (Answer: this shows that the constituent minerals contain iron and that the rock has been subjected to chemical weathering by oxidation).
4. Discuss the following major processes of chemical weathering :
 - a. **Dissolution** – dissociation of molecules into ions; common example includes dissolution of calcite and salt
 - b. **Oxidation**- reaction between minerals and oxygen dissolved in water
 - c. **Hydrolysis**- change in the composition of minerals when they react with water

Teacher Tips:

During the instruction (lecture or powerpoint presentation) students must take notes in their notebook. The teacher will monitor as the lesson progresses and randomly call on students to read what they have written for a particular topic.

Physical weathering (or mechanical weathering) disintegrates rocks, breaking them into smaller pieces. Chemical weathering decomposes rocks through chemical reactions that change the original rock-forming minerals. Weathering occurs as a response to the low pressure, low temperature, and water and oxygen-rich nature of the Earth's surface. Point out that physical weathering and chemical weathering almost always occur together in nature and reinforce each other.

5. Enumerate and discuss the factors that affect the type, extent, and rate at which weathering takes place:
- Climate** – areas that are cold and dry tend to have slow rates of chemical weathering and weathering is mostly physical; chemical weathering is most active in areas with high temperature and rainfall
 - Rock type** – the minerals that constitute rocks have different susceptibilities to weathering. Those that are most stable to surface conditions will be the most resistant to weathering. Thus, olivine for example which crystallizes at high temperature conditions will weather first than quartz which crystallizes at lower temperature conditions.
 - Rock structure**- rate of weathering is affected by the presence of joints, folds, faults, bedding planes through which agents of weathering enter a rock mass. Highly-jointed/fractured rocks disintegrate faster than a solid mass of rock of the same dimension
 - Topography**- weathering occurs more quickly on a steep slope than on a gentle one
 - Time**- length of exposure to agents of weather determines the degree of weathering of a rock

ENRICHMENT (15 MINS)

Break Me Down

- Divide the class into small groups of 3-5 students. Each group will need the following set of materials: antacid tablets, 2 clear cups, and stopwatch.
- Put equal volume of equal temperature water into 2 cups.
- Drop one whole antacid tablet into one of the cups. Record your observation and the time from when the tablet is added until it is completely dissolved and no traces of the tablet is visible.
- Break one tablet into smaller pieces by putting pressure on it and drop into the other cup. Record your observation and dissolution time of the tablet.
- Wash the cups making sure there are no pieces of antacid tablet left.
- Repeat steps 3 to 5 but this time use hot water.
- Fill the table with dissolution times (in seconds) they have recorded.

	Room temperature water	Hot water
Whole tablet		
Broken tablet		

8. Ask the students to answer the following questions. Discuss answers with the class.
- In which setup did the reaction occur most rapidly? In which setup did it occur most slowly?
 - What is the relationship between particle size and speed it takes for the tablet to dissolve? How does this relationship apply to weathering in nature?
 - In the activity you have just finished, how does mechanical weathering contribute to chemical weathering? How can you demonstrate the fact that chemical weathering can hasten mechanical weathering?
 - Compare dissolution times in room temperature water and hot water. What is the relationship between temperature and weathering rate?

EVALUATION (10 MINS)

Ask the students to get together in pairs and answer the following questions. Have 2 or 3 pairs discuss their answers in front of the class.

- List some everyday examples of weathering. Identify and explain whether these everyday occurrences show physical or chemical weathering. (Possible answers: Paint on walls gradually deteriorating, tree roots breaking concrete or rock, bleach removing stains on clothes, rust on a car, barely legible inscriptions in marble monuments, etc.)
- During your recent visit to the cemetery, you noticed the inscriptions on some headstones have become barely legible whereas inscriptions on others are sharp and clear. Cite three possible factors that contributed to the present state of the headstone inscriptions. (Possible answer: Possible factors which influenced the amount of weathering the tombstones have been subjected to: a. Age or length of time the tombstone has been exposed to weathering agents, b. Type of material, marble being more susceptible to dissolution than granite, c. Exposure to weathering agents, some tombstones are shaded by trees or have roof above them)

Possible answers to discussion questions:

- Broken tablet in hot water exhibited fastest reaction rates whereas whole tablet in room temperature water showed slowest dissolution times.
- The larger the surface area the faster reaction will proceed. In nature, smaller rocks weather faster than large rocks. Cracked and pitted surfaces will weather faster than smooth surfaces (refer to Fig. 1 for an illustrated guide).
- Breaking or crushing the tablet exposes more surface area. As mechanical weathering breaks rocks into smaller pieces, more surface area is exposed which renders the rock more susceptible to attack by agents of chemical weathering. Chemical weathering can speed up physical disintegration by weakening the bonds between grains, loosening them to fall out physically. Placing a few drops of water on the tablet would soften it making breaking/crushing a lot easier.
- Faster dissolution times in hot water. Chemical weathering proceeds more rapidly in higher temperature.

Lesson 9: Exogenic Processes (Erosion and Deposition)

Content Standard

The learners demonstrate an understanding of geologic processes that occur on the surface of the Earth such as weathering, erosion, mass wasting, and sedimentation.

Learning Competency

The learners make a simple map showing places where erosion may pose risks in the community. The learners explain how the products of weathering are carried away by erosion and deposited elsewhere (**S11/12ES-Ib-12**).

Specific Learning Outcomes

At the end of this lesson, the learners will be able to:

1. Identify the different agents of erosion and deposition
2. Describe characteristic surface features and landforms created and the processes that contributed to their formation

LESSON OUTLINE

Introduction	Presentation of Learning Objectives	3
Motivation	Sediment Jar Demonstration	5
Instruction	Lecture and discussion	40
Enrichment	Areas of erosion and deposition	15
Evaluation	Peer quiz	12

Materials

Jar with lid, sand, gravel, salt, board eraser, double-sided tape

Resources

- (1) Bykerk-Kaufmann, A. (2008). *Lab activity on sedimentary process* [Pdf file]. Retrieved from <http://www.csuchico.edu/~abykerk-kauffman/courses/nscl342/1101packet/S11%20NSCI%20342%20Packet%20Part%20B.pdf>
- (2) Coffey, P. & Mattox, S. (2006, March). *Take a tumble: Weathering and erosion using a rock tumbler* [Pdf file]. Retrieved from https://www.gvsu.edu/cms4/asset/DE36066F-E528-CF94-8F079306A8293D59/take_a_tumble.pdf
- (3) Department of Geology, University of Illinois at Urbana-Champaign. (2007). *Sculpting Earth with ice: Glaciers* [Lecture]. Retrieved from http://ijolite.geology.uiuc.edu/07FallClass/geo101/101%20Lectures/101_L37_GlaF07.html
- (4) Godard Space Flight Center. (n.d.). *Lesson 4A: Erosion and deposition*. Retrieved from <http://education.gsfc.nasa.gov/ess/Units/Unit4/U4L04A.html>
- (5) Jackson, H. (2000, November 15). *Rivers and streams, and erosional process* [Lecture]. Retrieved from <http://web.crc.losrios.edu/~jacksoh/lectures/rivers.html>
- (6) Lillquist, K. D. & Kinner, P. W. (2002). Stream tables and watershed geomorphology education. *Journal of Geoscience Education*, 50(5), 583-593. Retrieved from http://serc.carleton.edu/files/nagt/jge/abstracts/Lillquest_v50n5p583.pdf
- (7) Monet, J. (2016, January 6) *Unit 2: Fluvial processes that shape the natural landscape*. Retrieved from http://serc.carleton.edu/integrate/teaching_materials/energy_and_processes/activity_2.html
- (8) Monroe, J.S., Wicander, R., & Hazlett, R. (2007). *Physical Geology: Exploring the Earth* (6th ed.). Pacific Grove, CA: Thomson Brookes/Cole.
- (9) Nelson, S. A. (2015, December 1). *Earth & Environmental Sciences 1110: Physical Geology* [Lecture notes]. Retrieved from <http://www.tulane.edu/~sanelson/eens1110/index.html#Lecture%20Notes>
- (10) Tarbuck, E.J., Lutgens, F.K. & Tasa, D. (2014). *Earth: An Introduction to Physical Geology*. (11thed.). Upper Saddle River, NJ: Prentice Hall.
- (11) Tiwari, P. (n.d.). The Fluvial landforms and cycle of erosion. Retrieved from <http://www.geographynotes.com/geomorphology/the-fluvial-landforms-and-cycle-of-erosion/757>

INTRODUCTION (3 MINS)

1. Present the learning objectives
 - A. I can identify the different agents of erosion and deposition
 - B. I can describe characteristic surface features and landforms created and the processes that contributed to their formation
2. Write down the following key terms on the board:
 - A. Erosion
 - B. Deposition
 - C. Abrasion
 - D. Alluvial fans
 - E. Oxbow lake
 - F. Glacier
 - G. Arete
 - H. Drumlin
 - I. Dune
 - J. Deflation
 - K. Ventifacts
 - L. Barrier island
 - M. Spit
3. Ask the learners to construct a table with four columns labelled: **Key Terms, Can Define It, Have heard/read about It, No Idea about It**, and instruct them to rate their knowledge of the terms by writing a check on the corresponding column.
4. Have the learners write down the definition of each term in their own words, if they can.

Teacher Tip:

Learners have had prior exposure to most of these terms in pre SHS science. Have learners revise their definitions after the lecture.

MOTIVATION (5 MINS)

Activity: Sediments

1. Show learners a tray containing sand. Challenge them to think of as many ways as they can to move the sand from one end of the tray to the other.
2. Possible answers: blowing, tilting the tray, running water, pushing, etc.

INSTRUCTION/DELIVERY/PRACTICE (40 MINS)

WEATHERING VS. EROSION

1. **Weathering** — the disintegration and decomposition of rock at or near the Earth surface
2. **Erosion** — the incorporation and transportation of material by a mobile agent such as water, wind, or ice
3. Weathering occurs in situ, that is, particles stay put and no movement is involved. As soon as the weathering product starts moving (due to fluid flow) we call the process erosion.
4. Weathering, erosion/transportation, and deposition are **exogenic processes** that act in concert, but in differing relative degrees, to bring about changes in the configuration of the Earth's surface.

AGENTS OF EROSION

1. Running water

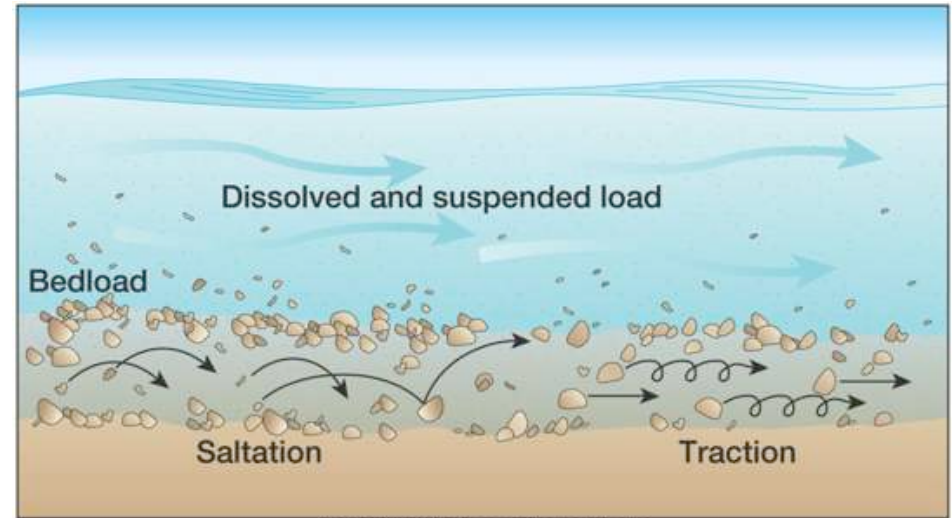
- a. Explain that "running water" encompasses both overland flow and stream flow. Differentiate overland flow and streamflow.
- b. Discuss the factors that affect stream erosion and deposition
 - i. **Velocity** – dictates the ability of stream to erode and transport; controlled by gradient, channel size and shape, channel roughness, and the amount of water flowing in the channel
 - ii. **Discharge** – volume of water passing through a cross-section of a stream during a given time; as the discharge increases, the width of the channel, the depth of flow, or flow velocity increase individually or simultaneously
- c. Summarize how various properties of stream channel change from its headwaters to its mouth.
 - i. From headwaters to mouth: Channel slope ↓, Channel roughness ↓, Discharge ↑, Channel size ↑, Flow velocity ↓
- d. Explain how streams erode their channels, transport, and deposit sediments. (Return to the learners' answers to questions during the motivation activity.)
 - i. Styles of erosion: Vertical erosion (downcutting), lateral erosion, headward erosion
 - ii. Streamflow erosion occurs through: Hydraulic action, abrasion, solution
 - iii. Streams transport their sediment load in three ways: in solution (**dissolved load**), in suspension (**suspended load**), sliding and rolling along the bottom (**bed load**)
 - iv. A stream's ability to transport solid particles is described by: competence (size of the largest

Teacher Tips:

- During the discussion (lecture or powerpoint presentation), instruct learners to take down notes. Randomly call on learners to read what they have written for the topic that is currently being discussed.
- Suggested outline: Explain the distinction between weathering and erosion. Define deposition and describe the general conditions that commonly lead to deposition of sediments. Highlight the thread connects these processes. Briefly review the hydrologic cycle to illustrate the role of the sun and gravity in driving these processes.
- You may explain the processes of weathering, erosion, and deposition in the context of systems, to help learners understand that the landscape can be imagined as a series of intimately linked components. Point out that exogenic processes are essentially driven by forces generated by the Sun-Earth system and by the pull of gravity. The sun's energy drives the water cycle and gravity controls rock and water movement downslope.
- Teacher may use the sediment jar to demonstrate sediment sorting. By this time most of the particles have settled to the bottom of the jar.

particle that can be transported by the stream) and capacity (maximum load a stream can transport under given conditions)

- v. Deposition occurs when a river loses its capacity to transport sediments. With decrease in velocity and competence, sediments start to settle out. River deposits are sorted by particle size.
- e. Explain how straight, braided, and meandering channels form.
- f. Enumerate and describe erosional and depositional landforms created by a stream:
 - i. Erosional landforms: River valleys, waterfalls, potholes, terraces, gully/ rills, meanders (exhibit both erosional and depositional features), oxbow lake, peneplane
 - ii. Depositional landforms: Alluvial fans/cones, natural levees, deltas



The different sediment loads of a stream and how they are transported. (Source: http://web.gccaz.edu/~lnewman/gph111/topic_units/fluvial/16_07.jpg)

2. Ocean or sea waves

- a. Define "wave." Identify the parameters by which a wave is described:
 - i. Crest and trough; wave length (L); wave height (H); steepness(H/L); period (T); velocity ($C=L/T$)
 - ii. Waves are classified based on generation force: wind-generated waves, tsunami, tides, seiches (We'll focus on wind-generated waves)
- b. List and discuss the factors that influence the height, length, and period of a wave and describe the motion of water within a wave. Describe how wave's velocity, length, and height change as the wave moves into shallow water.
 - i. Wind speed; wind duration; fetch (distance the wind has travelled across water)
 - ii. Orbital motion of water in waves. In deep water, there is

little or no orbital motion at depths greater than half the wavelength. As a wave moves into shallower water, it starts to 'feel bottom' at a depth equal to the wave base ($D=L/2$). C (velocity)↓, L ↓, H↑, T does not change as wave moves into shallow water.

- c. Explain how waves erode and move sediment along the shore.
 - i. Shoreline erosion processes: Hydraulic action, abrasion, corrosion
 - ii. Transport by waves and currents: Longshore current, beach drift
- d. Describe the features created by wave erosion and deposition.
 - i. Erosional features: wave-cut cliff, wave-cut platform, marine terrace, headland, stacks and sea arches
 - ii. Depositional features: beach, spit, baymouth bar, tombolo, barrier island

Teacher Tip:

To conclude lecture on wave erosion and deposition show learners a photo showing coastal erosion. Have the learners identify evidence in the photo that the coast is being eroded.

3. Glaciers

- a. **Glacier** — a moving body of ice on land that moves downslope or outward from an area of accumulation (Monroe et. al., 2007)
- b. Types of glaciers:
 - i. **Valley (alpine) glaciers** — bounded by valleys and tend to be long and narrow
 - ii. **Ice sheets (continental glaciers)** — cover large areas of the land surface; unconfined by topography. Modern ice sheets cover Antarctica and Greenland
 - iii. **Ice shelves** — sheets of ice floating on water and attached to the land. They usually occupy coastal embayments.
- c. Explain how glaciers form. Discuss the mechanisms that account for glacial movement.
 - i. Glaciers form in regions where more snow falls than melts. Snow accumulates then goes through compaction and recrystallization, eventually transforming into glacial ice
 - ii. Glaciers move to lower elevations by plastic flow due to great stress on the ice at depth, and basal slip facilitated by meltwater which acts as lubricant between the glacier and the surface over which it moves.
- d. Discuss the processes of glacial erosion. Describe the features created by erosion due to glaciers.
 - i. Ice cannot erode the bedrock on its own. Glaciers pick up rock fragments and use them to abrade the surfaces over which they pass.

- ii. Processes responsible for glacial erosion: Plucking (lifting pieces of bedrock beneath the glacier) and abrasion (grinding and scraping by sediments already in the ice). Plucking is responsible for creating rochemoutonnee. Abrasion yields glacial polish and glacial striations. (Teacher may demonstrate glacial erosion by sticking double-sided tape on one side of a board eraser, press down and push the eraser with tape side down along the length of a paper sprinkled with a mixture of fine and coarse-grained sand. The particles are picked up and pushed to a different location. This left indentations and parallel grooves on the paper)
- iii. Landforms created by valley glacier erosion: cirque, tarn, arête, horn, hanging valley, u-shaped valley, pater noster lakes, fjord
- e. Landforms created by continental glaciers: roche moutonnée
- f. Distinguish between the two types of deposits by glaciers. Describe the landforms associated with each deposit.
 - i. All glacial deposits are called glacial drift, and are comprised of two types: (1) till, deposited directly by ice, unsorted, and composed of many different particle sizes; and (2) stratified drift, deposited by the glacial meltwater and thus has experienced the sorting action of water. As its name suggests, deposits are layered and exhibit some degree of sorting.
 - ii. Moraines are ridges of till, classified according to their position relative to the glacier: lateral (edge of valley glaciers) moraine; end (front or head of glacier) moraine; ground (base of glacier) moraine; and medial (middle) moraine. Medial moraines form when lateral moraines join as tributary glaciers come together. Other till features: erratics and drumlins.

Teacher Tip:

Demonstrate glacial erosion by sticking double-sided tape on one side of a board eraser. Press down and push the eraser, tape side, down along the length of a paper sprinkled with a mixture of fine and coarse-grained sand. The particles are picked up and pushed to a different location, leaving indentations and parallel grooves on the paper.

4. Wind

- a. Describe the processes associated with erosion and transportation by wind.
 - i. Wind erodes by: deflation (removal of loose, fine particles from the surface), and abrasion (grinding action and sandblasting)
 - ii. Deflation results in features such as blowout and desert pavement. Abrasion yields ventifacts and yardangs.
 - iii. Wind, just like flowing water, can carry sediments such as: (1) bed load (consists of sand hopping and bouncing through the process of saltation), and (2) suspended load (clay and silt-sized particles held aloft).

- b. Identify features associated with aeolian erosion and deposition. Describe their characteristics and the processes by which they are formed.
 - i. Features created by wind erosion: blowout and desert pavement created by deflation, ventifacts and yardangs resulting from abrasion
 - ii. Two types of wind deposits: (1) dunes which are hills or ridges of wind-blown sand, and (2) loess which are extensive blankets of silt that were once carried in suspension
 - iii. The size, shape, and arrangement of dunes are controlled by factors such as sand supply, direction and velocity of prevailing wind, and amount of vegetation. There are six major kinds of dunes: barchan dunes, transverse dunes, barchanoid dunes, longitudinal dunes, parabolic dunes, star dunes.
 - iv. The primary sources of sediments contributing to loess deposits are deserts and glacial deposits.

5. Groundwater

- a. Describe how groundwater erodes rock material.
 - i. The main erosional process associated with groundwater is solution. Slow-moving groundwater cannot erode rocks by mechanical processes, as a stream does, but it can dissolve rocks and carry these off in solution. This process is particularly effective in areas underlain by soluble rocks, such as limestone, which readily undergoes solution in the presence of acidic water.
 - ii. Rainwater reacts with carbon dioxide from atmosphere and soil to form a solution of dilute carbonic acid. This acidic water then percolates through fractures and bedding planes, and slowly dissolves the limestone by forming soluble calcium bicarbonate which is carried away in solution.
- b. Describe karst topography and its associated landforms.
 - i. Karst topography —a distinctive type of landscape which develops as a consequence of subsurface solution. It consists of an assemblage of landforms that is most common in carbonate rocks, but also associated with soluble evaporate deposits.
 - (1) Cave/Cavern – forms when circulating groundwater at or below the water table dissolves

carbonate rock along interconnected fractures and bedding planes. A common feature found in caverns is dripstone, which is deposited by the dripping of water containing calcium carbonate. Dripstone features are collectively called speleothems, and include stalactites, stalagmites, and columns

- (2) Sinkholes (Dolines) – circular depressions which form through dissolution of underlying soluble rocks or the collapse of a cave’s roof.
- (3) Tower karst – tall, steep-sided hills created in highly eroded karst regions.

6. Gravity

- a. **Mass wasting** — the downslope movement of soil, rock, and regolith under the direct influence of gravity
- b. Factors that control mass wasting processes include:
 - i. As the slope angle increases, the tendency to slide down the slope becomes greater.
 - ii. Role of water: adds weight to the slope, has the ability to change angle of repose, reduces friction on a sliding surface , and water pore pressure reduces shear strength of materials
- c. State that there are various types of mass movements, which will be discussed in upcoming lessons.

ENRICHMENT (15 MINS)

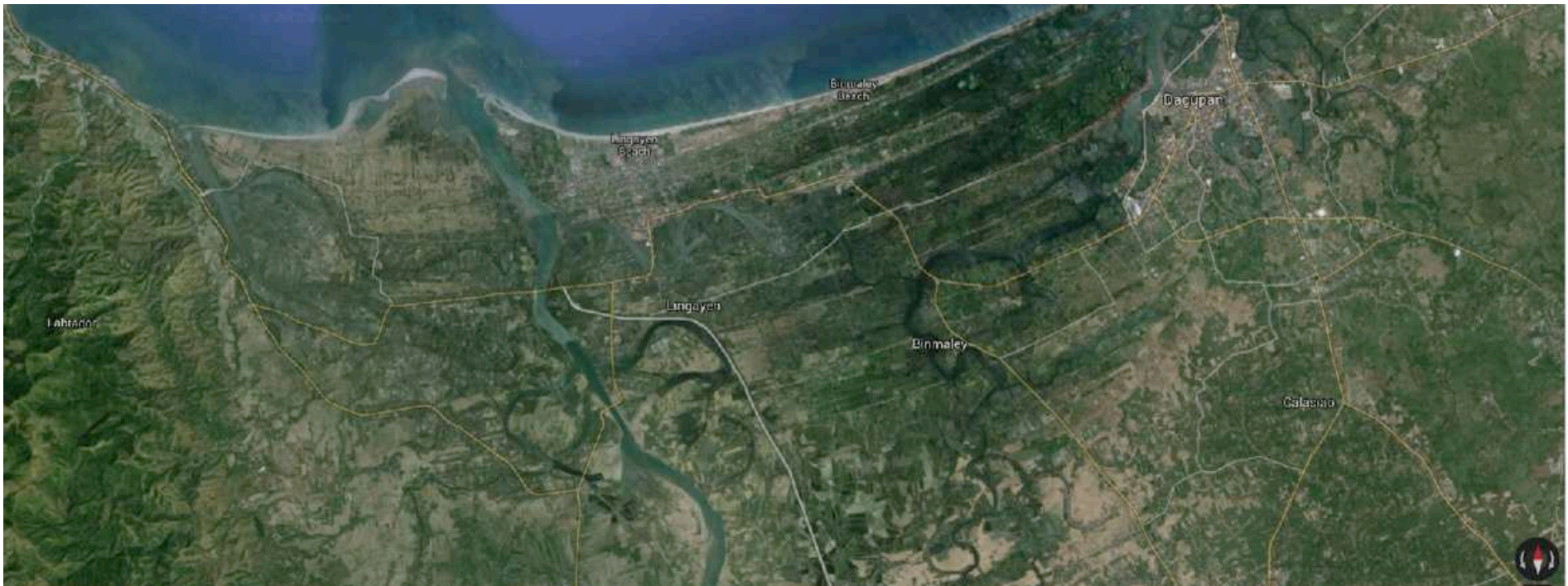
Activity: Annotated sketch of areas of erosion and deposition

Have learners use a map to locate a river or coastline nearest their community. Direct them to identify locations of erosion and deposition by making an annotated sketch of the river or coast. Explain how the different erosional and depositional features may have formed. Predict how the river/coast may change shape in the future, and identify areas susceptible to fluvial/coastal erosion. (A satellite image from Google Earth of the lower and middle course of Agno River, provided in an appendix to this teaching guide, may be used for this activity).

EVALUATION (12 MINS)

Have each learner formulate three review questions that cover the content of the lesson. Break the class into pairs and instruct learners that they will quiz their partners using the questions they have prepared. Each pair should discuss the correct answers with each other, and submit their questions and

	EXCEEDS EXPECTATIONS	MEETS EXPECTATIONS	NEEDS IMPROVEMENT	NOT VISIBLE
Erosion/deposition mapping 1. Sketches are drawn accurately and clearly labelled. 2. Correctly identified areas of erosion and deposition. 3. Uses appropriate key terms learned in the lecture to explain the formation of features identified.				
Peer Quiz 1. Questions are pertinent to the topic and stimulate thought and inquiry. 2. The questions encourage learners to evaluate and analyze in order to arrive at an answer. 3. Answer is accurate and complete, demonstrating a good understanding of concepts involved.				



Lesson 10: Exogenic Processes (Mass Wasting)

Content Standard

The learners will be able to develop and demonstrate an understanding of geologic processes that occur on the surface of the Earth such as weathering, erosion, mass wasting, and sedimentation.

Learning Competency

The learners make a report on how rocks and soil move downslope due to the direct action of gravity **(S11/12ES-Ib-13)**

Specific Learning Outcomes

At the end of this lesson, the learners will be able to:

1. Identify the controls and triggers of mass wasting
2. Distinguish between different mass wasting processes

LESSON OUTLINE

Introduction	Presentation of objectives and terms	2
Motivation	Mass wasting analogy	3
Instruction	Lecture proper and discussion	30
Enrichment	Scenarios	15
Evaluation	Examine a photograph	10

Materials

Ball, paper cup, paper plate, sand, water

Resources

This lesson is adapted from activities and information at the following sites:

- (1) <http://www.tulane.edu/~sanelson/eens1110/massmovements.htm> (Accessed: 12/29/2015) <http://lessonplanspage.com/sciencegravityerosionmasswasting8htm/> (Accessed: 12/28/2015) <http://landslides.usgs.gov/learn/prepare.php> (Accessed: 1/15/2016) <http://www.miracosta.edu/home/MEggers/MRE%20MassWastingCh7.pdf> (Accessed: 1/11/2016) <http://www.nature.com/scitable/topicpage/lesson-8-landslides-hazards-8704578> (Accessed: 12/29/2015) Textbook sources:
- (2) Tarbuck, E.J., F.K. Lutgens, and Tasa, D. 2014. Earth An Introduction to Physical Geology. Eleventh Edition. Prentice Hall.
Monroe, J.S., Wicander, R., and Hazlett, R. 2007. Physical Geology: Exploring the Earth 6th edition. Thomson Brookes/Cole.

INTRODUCTION (2 MINS)

1. Introduce the following learning objectives and important terms
 - a. I can identify the controls and triggers of mass wasting
 - b. I can distinguish between different mass wasting processes
2. Introduce the list of key terms that learners will encounter.
 - a. Mass wasting
 - b. Landslide
 - c. Regolith
 - d. Angle of repose
 - e. Debris flow
 - f. Creep
 - g. Slump
 - h. Rock slide
 - i. Submarine slump
3. Copy the key terms on the board. Have the students write the definitions in their own words.

MOTIVATION (3 MINS)

Place a blackboard eraser on the table. Ask students what will happen –nothing. Place the eraser on a smooth, slanted surface –the eraser will slide down. Explain that similar to the blackboard on a slanted surface, rocks and rock debris can also move down-slope through the process called mass wasting.

INSTRUCTION /DELIVERY/PRACTICE (30 MINS)

Give a demonstration/lecture/simulation

Lecture proper (Outline)

1. Define mass wasting as the downslope movement of rock, regolith, and soil under the direct influence of gravity (Tarbuck, et.al. 2014) Emphasize gravity as the main immediate agent in mass movement. Discuss that mass movements are an important part of the erosional processes whereby mass wasting moves material from higher to lower elevations where streams or glaciers can then pick up the loose materials and eventually move them to a site of deposition.

Teacher Tip:

Students have had prior exposure to most of these terms in pre SHS science. Have students revise their definitions after the lecture.

Teacher Tip:

During the instruction (lecture or powerpoint presentation) students must take notes in their notebook. The teacher will monitor as the lesson progresses and randomly call on students to read what they have written for a particular topic.

Point out that weathering, mass wasting, and erosion constitute a continuum of interacting processes.

2. Discuss the meaning of the word landslide. Landslide is a common term used by many people to describe sudden event in which large quantities of rock and soil plunge down steep slopes. This term encompasses all downslope movement whether it be bedrock, regolith, or a mixture of these.
3. Discuss the controlling factors in mass wasting

a. **Slope Angle**

- i. Component of gravity perpendicular to the slope which helps hold the object in place
- ii. Component of gravity parallel to the slope which causes shear stress and helps move objects downslope
- iii. On a steep slope, the slope-parallel component increases while the slope- perpendicular component decreases. Thus the tendency to slide down the slope becomes greater. All forces resisting movement downslope can be grouped under the term shear strength which is controlled by factors such as frictional resistance and cohesion of particles in an object, pore pressure of water, anchoring effect of plant roots. When shear stress > shear strength , downslope movement occurs

b. **Role of water**

- i. Water has the ability to change the angle of repose (the steepest slope at which a pile of unconsolidated grains remain stable). To demonstrate this concept, the teacher will create a sand hill using dry, damp, and water-saturated sand by flipping a paper cup full of the sand material upside down on a paper plate. Note that dry, unconsolidated grains will form a pile with slope angle determined by its angle of repose. For slightly wet sand, a high angle of repose will be observed while a very low angle of repose will be observed for water-saturated sand. It is the water in the partially saturated sand that gives it its strength. More correctly, it is surface tension that holds the grains together and helps them stick more than they do when they are dry. The opposite happens for sand with too much water. In saturated sand, all the pore spaces are filled with water eliminating grain to grain contact. Water in the interconnected pores exerts pressure which then reduces the shearing force between the particles. The angle of repose is also reduced.
- ii. Addition of water from rainfall or snowmelt adds weight to the slope.
- iii. Water can reduce the friction along a sliding surface

Teacher Tip:

This demonstration, similar to building a sandcastle on the beach, shows that there is an optimum dampness in the sand which results in strongest shapes. If the sand is totally dry it is impossible to build steep-faced walls as the material easily crumbles. If sand is wet, it can build a vertical wall. With water-saturated sand, the material flows like fluid and will not be able to remain in position as a wall.

c. **Presence of troublesome earth materials**

- i. Expansive and hydrocompacting soils – contain a high proportion of smectite or montmorillonite which expand when wet and shrink when they dry out,
- ii. Sensitive soils – clays in some soils rearrange themselves after dissolution of salts in the pore spaces. Clay minerals line up with one another and the pore space is reduced.
- iii. Quick clays – water-saturated clays that spontaneously liquefies when disturbed

d. **Weak materials and structures**

- i. Become slippage surfaces if weight is added or support is removed (bedding planes, weak layers, joints and fractures, foliation planes)

4. Classify mass wasting processes

a. **Slope failures** - sudden failure of the slope resulting in transport of debris downhill by rolling, sliding, and slumping.

- i. **Slump** – type of slide wherein downward rotation of rock or regolith occurs along a curved surface
- ii. **Rock fall and debris fall**– free falling of dislodged bodies of rocks or a mixture of rock, regolith, and soil in the case of debris fall
- iii. **Rock slide and debris slide**- involves the rapid displacement of masses of rock or debris along an inclined surface

b. **Sediment flow** - materials flow downhill mixed with water or air; Slurry and granular flows are further subdivided based on velocity at which flow occurs

- i. **Slurry flow** – water-saturated flow which contains 20-40% water; above 40% water content, slurry flows grade into streams
 - (1) Solifluction – common wherever water cannot escape from the saturated surface layer by infiltrating to deeper levels; creates distinctive features: lobes and sheets of debris
 - (2) Debris flow – results from heavy rains causing soil and regolith to be saturated with water; commonly have a tongue-like front; Debris flows composed mostly of volcanic materials on the flanks of volcanoes are called lahars. Rodolfo, K.S. (2000) in his paper “The hazard from lahars and jokulhaups” explained the distinction between debris flow, hyperconcentrated flow and mudflow: debris flow contains 10-25 wt% water,

Teacher Tips:

Before discussing in detail the mass wasting classification, write down on the board the different mass wasting processes (slump, rock fall, debris fall, mudflow, grain flow, etc.). Emphasize that the terms are very descriptive and that it is fairly simple to figure out where these terms come about. Have the students predict based on the terms the type of material and how the material moves. For example, in the term rock fall, the word “rock” indicates the type of material and “fall” indicates the movement involves falling.

Most mass wasting processes grade into one another without clear boundaries between them making classification into types somewhat difficult. There is not one universal classification scheme for mass wasting processes. Even the term “mass wasting” is not universal as some writers prefer the term “mass movement”. The classification used in this teaching guide divides the processes into 2 broad categories: slope failures and sediment flow.

hyperconcentrated stream flow has 25-40 wt% water, and mudflow is restricted to flows composed dominantly of mud

- (3) Mud flow – highly fluid, high velocity mixture of sediment and water; can start as a muddy stream that becomes a moving dam of mud and rubble; differs with debris flow in that fine-grained material is predominant

- ii. **Granular flow** – contains low amounts of water, 0-20% water; fluid-like behavior is possible by mixing with air

- (1) **Creep** – slowest type of mass wasting requiring several years of gradual movement to have a pronounced effect on the slope ; evidence often seen in bent trees, offset in roads and fences, inclined utility poles. Creep occurs when regolith alternately expands and contracts in response to freezing and thawing, wetting and drying, or warming and cooling
- (2) **Grain flow** – forms in dry or nearly dry granular sediment with air filling the pore spaces such as sand flowing down the dune face
- (3) **Debris avalanche** – very high velocity flows involving huge masses of falling rocks and debris that break up and pulverize on impact; often occurs in very steep mountain ranges. Some studies suggest that high velocities result from air trapped under the rock mass creating a cushion of air that reduces friction and allowing it to move as a buoyant sheet

5. Describe subaqueous mass wasting

Subaqueous mass movement occurs on slopes in the ocean basins. This may occur as a result of an earthquake or due to an over-accumulation of sediment on slope or submarine canyon. 3 types:

- a. **Submarine slumps** - similar to slumps on land
- b. **Submarine debris flow** – similar to debris flows on land
- c. **Turbidity current** – sediment moves as a turbulent cloud

Teacher Tip:

Usually, one “landslide” event would involve a combination of two or more types of mass movement. It should be noted that one type of mass wasting can evolve into another type as the body of rock/sediments move downslope. For example, a slump would have a flow component near its toe.

6. Discuss the events that trigger mass wasting processes.
 - a. **Shocks and vibrations** – earthquakes and minor shocks such as those produced by heavy trucks on the road, man-made explosions
 - b. **Slope modification** – creating artificially steep slope so it is no longer at the angle of repose
 - c. **Undercutting** – due to streams eroding banks or surf action undercutting a slope
 - d. **Changes in hydrologic characteristics** – heavy rains lead to water-saturated regolith increasing its weight, reducing grain to grain contact and angle of repose;
 - e. **Changes in slope strength** – weathering weakens the rock and leads to slope failure; vegetation holds soil in place and slows the influx of water; tree roots strengthen slope by holding the ground together
 - f. **Volcanic eruptions** - produce shocks; may produce large volumes of water from melting of glaciers during eruption, resulting to mudflows and debris flows
7. Enumerate and discuss some landslide warning signs (Source: <http://landslides.usgs.gov/learn/prepare.php>)
 - a. Springs, seeps, or saturated ground in areas that have not typically been wet before.
 - b. New cracks or unusual bulges in the ground, street pavements or sidewalks.
 - c. Soil moving away from foundations.
 - d. Ancillary structures such as decks and patios tilting and/or moving relative to the main house.
 - e. Tilting or cracking of concrete floors and foundations.
 - f. Broken water lines and other underground utilities.
 - g. Leaning telephone poles, trees, retaining walls or fences.
 - h. Offset fence lines.
 - i. Sunken or down-dropped road beds.
 - j. Rapid increase in creek water levels, possibly accompanied by increased turbidity (soil content).
 - k. Sudden decrease in creek water levels though rain is still falling or just recently stopped.
 - l. Sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb.
 - m. A faint rumbling sound that increases in volume is noticeable as the landslide nears.
 - n. Unusual sounds, such as trees cracking or boulders knocking together, might indicate moving debris.

Teacher Tip:

In considering this landslide warning signs, one must put observations into perspective. One aspect may not always tell the whole story.

ENRICHMENT (15 MINS)

1. Three Friends in A Valley (Activity copied from: <http://www.nature.com/scitable/topicpage/lesson-8-landslides-hazards-8704578>)
As a pre-class reading assignment, have students read the story “Three Friends In A Valley” and answer the accompanying questions.
2. Divide the class into small groups of 3-4 students and have them discuss among themselves their answers. In class, lead the discussion while at the same time allowing opportunity for thorough exchange of ideas among students.

Three friends (Sara, Amira, and Gozen) live in the small city of Shahrabad, which is located in a beautiful mountain valley. The bottom of the valley has a small river running through it. The walls of the valley have land that includes forests and farms. The friends have lived there since they were young and they know that earthquakes sometimes happen there. They have only felt one small earthquake, but their parents and grandparents have told stories about some strong earthquakes that have happened in the area. Sometimes, during extreme weather like heavy snow or rain, the road that comes into Shahrabad from a nearby city is closed because rocks have fallen on the road or the road has washed away.

Sara and Amira live next to each other on farms located on slopes in the valley. Sara's farm used to have a natural spring at a crack between two rocks that produced drinking water for both Sara's and Amira's families, but the spring stopped producing water about a year ago. Recently, a neighbor has started complaining that some parts of his land have become very soggy and soaked with water, especially near the bottom of the valley.

Question 1: What are natural springs, and what are a couple of reasons why the spring on Sara's farm stopped giving water?

Potential answers: Springs occur when water flows through cracks below the Earth's surface. The water can be a mix of rain water, water from underground channels that travel downhill toward the river, or water that is pushed up from deep underground in the deepest parts of the Earth, which has not ever before been to the surface. Sometimes springs located very close to each other on the surface of the Earth have completely different paths that the water in each follows. The water that is soaking the neighbor's land may or may not be related to the water that used to come out of the

spring; however, both of the changing events indicate that the land that Sara, Amira, and the neighbor live on is undergoing movements that may not be visible on the surface.

The spring might have stopped because of some small change in the path of the water due to small movements of the ground, or because the source of the water has become empty. The changes in the path of the water could have occurred deep in the Earth or just a couple of meters beneath where the spring is located. When the water flows through narrow cracks, very small shifts in the ground can stop the flow of water.

Sara's and Amira's farm share a wooden fence to keep their farm animals from wandering around. Sara and Amira often climb over the fence to play in the forest around their farm. About three years ago, they noticed that the fence posts were sloped at an angle at one spot in the fence near their path to the forest, and they were concerned that climbing over the fence was pushing the fence over. They changed their path so they didn't have to climb over the fence and then gradually forgot about the sloping fence posts. But the fence posts continued to tip over, little by little, without anyone noticing the low part of the fence. Until one day, about a month ago, a donkey got away by jumping over the low part of the fence. They helped their fathers fix the fence and straighten the fence posts so the donkey couldn't get away.

Question 2: What are some possible reasons for why the fence is slowly tipping over?

Potential answers: There are many answers possible that don't relate to landslide hazards. The fence could be old and the wood falling apart. The donkey could be pushing on the fence to eat some tasty grass that grows outside of that part of the fence. But the ground could also be moving very slowly beneath the farm, causing the fence posts to point uphill over the years. The fact that the spring stopped giving water may support this idea even further, especially if the path of the water to the surface was broken because the ground had shifted very slightly.

Gozen lives down in the city in a house. Sometimes all of the friends gather there to have dinner and listen to the radio or watch television. From where her family eats dinner, they can see the river. Her father helps to build and fix pipes that move water for farmers in the valley, and he also helps to build and fix houses. A wealthy man has just built a house above a very steep hill that has a beautiful view of the valley, and he even paid just to have electricity from the city strung on wires up the hill to the house. But the rooms already have cracks in the walls on the side of the house near the steep hill. Some of the windows and doors have also become very difficult to open and close.

Gozen's father has been working there the past few days and he jokes about how the wealthy man complains that his house was not built very well by workers from a nearby city.

Question 3: What are some possible reasons for the cracks in the walls? What are some ways to find out what is really happening?

Potential answers: Again, the wealthy man may be right and the walls were indeed poorly built. Oftentimes, houses also settle naturally as they age and cracks form as the house comes to rest on the ground. However, the cracks are forming on the walls on the sides nearest the steep hill, which may indicate that the part of the house that rests on ground above the steep hill may be on unstable ground that is slowly creeping down the hill. Doors and windows can become difficult to open and close because the house is changing shape as the ground moves beneath it, causing the frames to become misshapen. Also, if the ground was naturally unstable prior to building the house, the added load of the new house may be speeding the rate of movement of the creeping slope. Unstable ground or ground that is creeping is much more likely to release during a triggering event such as an earthquake or heavy rainfall. There are many ways to tell what the real cause of the cracks may be. Other indications, such as the bending of pipes, fences, footpaths, or roads, can be found to see if the ground is moving. If the ground is shifting, then electrical wires attached to polls in the ground near the edge of the hill will become very tight as the polls move with the ground.

One day, the three friends decide to go play in the forest together. They travel farther up the hill than they had ever gone before. They find a very interesting bunch of very tall trees whose trunks grow out of the ground at an angle before the trees turn straight and point up into the air like a normal tree (figure 2). Some of the trees have such a sharp angle that the girls can sit in the angle of the trees like a comfortable chair with their feet dangling down the slope of the hill! Most of the trees are curved in the same direction in the middle. The three friends name it the Sideways Forest.

Question 4: What would cause trees to grow like this?

Potential answers: Trees always grow up toward sunlight, so presumably the trees initially grew at a different angle when they were young. The fact that the trees were all curved in the same direction, and that they were all located next to each other, might indicate that the ground beneath the Sideways Forest is all shifting in one direction. The trees are all much older than the girls, implying that the ground has been moving for a very long time. This might mean that the ground above the

farm is unstable and could be dislodged in the event of heavy rain, an earthquake, or human activities like road construction. Figure 2 shows the shape of a tree that may indicate a history of ground creep, when exhibited by groups of trees located together.

One day, while the friends are walking back home from school, there is an earthquake. It is strong enough to shake many of the buildings around them, and the earthquake is over after about a minute. They are just as far away from Gozen's home as from Sara's and Amira's farms.

Question 5: Where should the friends go first?

Potential answers: There are many reasons to go to Gozen's house first. Gozen has a radio and television, so they can hear about the damage caused by the earthquake and whether emergency services are being delivered. The radio or television, if they are functioning immediately after the earthquake, may also have information on any developing weather system that may be coming in that could make the situation created by the earthquake even worse, such as heavy rain or snowfall. In addition, the combination of observations the girls have noticed around Amira's and Sara's farms indicate that the ground might be unstable and prone to landslide if another earthquake occurs.

Knowing that the farmland is unstable, it is natural for the girls to want to make sure that their families and homes are safe. At that moment it is very dangerous to go there because the possibility for aftershocks is high. Since the girls are safe, they should first make contact with a parent or family friend to let their parents know they are safe and find out what has happened in order that they can make an informed decision about what to do next, while conserving water, food, and medical supplies. The families are all fine, and they meet at Gozen's house to talk about what happened. Through the radio they find out that there has been an earthquake that has caused numerous landslides throughout the region. The neighbor whose land was becoming soaked with water reported that, in some places on his land, the surface had broken into cracks and the smooth slope had become shaped like stairs. The road has been blocked by some falling rocks, but the families have some food stored away for when the road is closed. Gozen's dad says that many pipes have been broken in several places, so there is no water to be gathered through the city's water system. They send the friends down to the river to gather some water to support the families. While the three friends are at the river, they notice that the water level is much lower than it had been the day before.

Question 6: What are some possible causes for the low river water level, and what should the girls do about it?

Potential answers: In river valleys that are likely to experience landslides after earthquakes, a sudden decrease in river water levels may indicate a landslide dam has formed upstream of the city. A landslide dam occurs when a landslide has blocked a river or stream, causing water to build up behind it. This causes flooding upstream and a drought or decreased water flow downstream. Landslide dams can be extremely dangerous because they are usually highly unstable. As the water builds up behind the dam, the landslide becomes saturated with water and can break catastrophically, flooding all areas downstream with little or no warning. Recall the instability of water-saturated unconsolidated materials observed during the liquefaction exercise in Lesson 7.

The three friends should notify their parents or other city officials immediately of this possibility so that they can determine whether a landslide dam has formed. If action is taken quickly, the water behind the landslide dam can be released gradually before it builds up to dangerous levels. Even children can save entire communities!

The three friends told their parents immediately about the water level, who in turn alerted city officials. A small landslide dam had formed upriver, but it was not large enough to be a concern. All three families stayed at Gozen's house for a few days as aftershocks were felt, but none of them was as big as the original earthquake. While there had been no landslides occurring on their farms during this series of earthquakes, the families became concerned about future earthquakes or other triggering events that could cause them to lose their farmlands and houses. They began to discuss ways of preventing landslides from taking place on their land.

EVALUATION (10 MINS)

1. Instruct students to write a short account, based on the photo, of changes which could occur on the slope to reduce its stability and allow mass movement to take place.
2. On the photo, rock layers dipping toward the ocean creates a classic situation for a rockslide/debris slide. Weaker rock layers may act as slippage surface causing the overlying layers to slide into the sea. Following a heavy rain, mass movement may occur on the dipping layers. Earthquake, undercutting thru surf action or a combination of these may also trigger mass movement.

Lesson 11: Endogenic Processes

Content Standard

The learners demonstrate an understanding of the geologic processes that occur within the Earth. The learners shall be able to make a simple map showing places where erosion and landslides may pose risks in the community.

Learning Competencies

The learners describe where the Earth's internal heat comes from **(S11/12ES-Ib-14)** and describe how magma is formed (magmatism) **(S11/12ES-Ic-15)**

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Know the sources and significance of the Earth's internal heat
2. Understand and explain the requirements for magma generation

LESSON OUTLINE

Introduction	Communicate Learning Objectives	3
Motivation	Class participation	3
Instruction	Discussion	24
Practice	Chocolate Mantle Convection Activity	15

Materials

1 flat pan (or 500ml tin ice cream can), 1 small candle, pan holder (higher than the candle), clean water, 1 cup chocolate/cocoa powder (to represent the lithosphere)

Resources

- (1) Carlson, D. H., Plummer, C. C., & Hammersley L. (2011). *Physical Geology: Earth Revealed* (9th ed., pp. 46-47). New York, NY: McGraw-Hill Education.
- (2) Heat and convection in the Earth. (n.d.). Retrieved from <http://www.ucl.ac.uk/EarthSci/people/lidunka/GEOL2014/Geophysics8%20-%20Thermal%20evolution/Heat.htm>
- (3) Kirkland, K. (2010.) *Earth Sciences: Notable Research and Discoveries* (pp. 18-21). New York, NY: Facts on File, Inc.
- (4) Marshak, S. (2013). *Essentials of Geology* (4th ed., pp. 99-100). New York, NY: W. W. Norton, Inc.
- (5) Merck, John. (n.d.). The rock cycle and igneous rocks I (online lecture). Retrieved from <http://www.geol.umd.edu/~jmerck/geol100/lectures/10.html>
- (6) Polanco, L. J. (2010, March 22). *Hot chocolate mantle convection demonstration* [Video file]. Retrieved from <https://www.youtube.com/watch?v=PdWYBAOqHrk>
- (7) Tarbuck, E. J., Lutgens, F. K., Tsjjita, J. C., & Hicock, S. R. (2014). *Earth An Introduction to Physical Geology* (pp. 134-136). Ontario, Canada: Pearson Education Canada

INTRODUCTION (3 MINS)

1. Communicate learning objectives
 - a. I can identify the sources of the Earth's internal heat and describe the different processes responsible for the transfer of heat.
 - b. I can explain the different conditions required in the generation of magma.
2. Review
 - a. The different layers of the Earth
 - b. The rock cycle and the definition of magma

Teacher Tip:

Introduce the learning objectives using the suggested protocols: verbatim, own Words, read-aloud.

MOTIVATION (3 MINS)

1. Show the students a piece of igneous rock. Ask the students the following:
 - a. How is an igneous rock formed?
 - b. If magma is defined as molten rock material, do you need to melt rocks to form magma?
 - c. Is temperature increase solely responsible for the melting of rocks?
 - d. Where and how is magma formed?

Teacher Tips:

- Make sure to differentiate between magma and lava.
- Remind the students of the internal structure of the Earth. Temperature increases with depth. Shouldn't all of the Earth's interior be molten?

INSTRUCTION DELIVERY (24 MINS)

HEAT IN THE INTERIOR OF THE EARTH

1. Two categories of the internal heat sources of the Earth: (<http://www.ucl.ac.uk/EarthSci/people/lidunka/GEOL2014/Geophysics8%20-%20Thermal%20evolution/Heat.htm>).
 - a. Primordial heat: heat from accretion and bombardment of the Earth during the early stages of formation. If you hit a hammer on hard surface several times, the metal in the hammer will heat up (kinetic energy is transformed into heat energy).
 - b. Radioactive heat (the heat generated by long-term radioactive decay): its main sources are the four long-lived isotopes (large half-life), namely K^{40} , Th^{232} , U^{235} and U^{238} that made a continuing heat source over geologic time.

2. The estimated internal temperature of the Earth (Carlson, D. H. et al, Physical Geology Earth Revealed, 2011, p 47 and <http://www.geol.umd.edu/~jmerck/geol100/lectures/10.html>)
 - a. The mantle and asthenosphere are considerably hotter than the lithosphere, and the core is much hotter than the mantle.
 - b. Core-mantle boundary: $3,700^{\circ}\text{C}$
 - c. Inner-core – outer-core boundary: $6,300^{\circ}\text{C} \pm 800^{\circ}\text{C}$
 - d. Earth's center: $6,400^{\circ}\text{C} \pm 600^{\circ}\text{C}$
3. Redistribution of the Earth's heat:
 - a. Simultaneous conduction, convection and radiation
 - b. Convection occurs at the mantle, but not between the core and mantle, or even between the asthenosphere and lithosphere (except at sea-floor spreading zones). The only heat transfer mechanism in these transition zones is through conduction.

Teacher Tips:

- Emphasize that temperature increases with depth, yet the mantle and inner core remain solid!
- Review the concepts of conduction, convection and radiation.

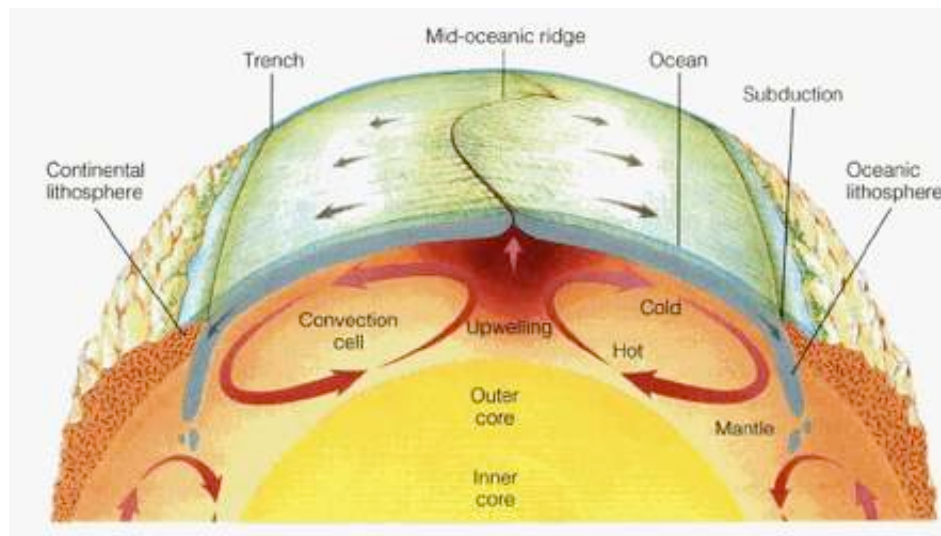
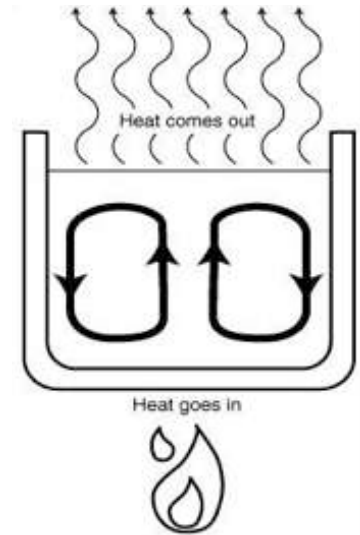


Diagram illustrating how heat is transferred in the Earth's interior. (source: <http://www.ucl.ac.uk/EarthSci/people/lidunka/GEOL2014/Geophysics8%20-%20Thermal%20evolution/Heat.htm>).

4. The concept of convection can be explained by comparing it to coffee preparation (based on the examples sourced from <http://www.geol.umd.edu/~jmerck/geol100/lectures/10.html>)
 - a. Mechanisms that occur when boiling water:
 - i. There is a heat source at the bottom of the water.
 - ii. The heat rises to the top from the bottom, causing the surface water to become hot. It radiates its heat into the air and then cools.
 - iii. The cooler water sinks into the space vacated by the ascending warmer water. This cooler water starts to warm up, while the water that rises starts to cool.
 - iv. The process continues, forming a top-to-bottom circulation of water.
 - b. Observations after pouring in the coffee (while the water is still hot):
 - i. The top portion has a relatively lighter color, compared to the lower zone. This represents the top of a convection cell.
 - ii. Condensing water vapor marks the top of rising columns of warm water. The dark line separating them marks the location of sinking cooler water.



- Ask the students for the boiling temperature of water. Most of the students will answer 100°C. The complete answer should be 100°C at 1 atm. Pressure is an important variable.
- Convection cell – the unit of a convective circulation

MAGMA FORMATION

1. The special conditions required for the formation of magma (Marshak, et al, Essentials of Geology, 2013, pp 99-100):
 - a. Crust and mantle are almost entirely solid, indicating that magma only forms in special places where pre-existing solid rocks undergo melting.
 - b. Melting due to decrease in pressure (decompression melting): The decrease in pressure affecting a hot mantle rock at a constant temperature permits melting forming magma. This process of hot mantle rock rising to shallower depths in the Earth occurs in mantle plumes, beneath rifts and beneath mid-ocean ridges.
 - c. Melting as a result of the addition of volatiles (flux melting): When volatiles mix with hot, dry rock, the volatile decreases the rock's melting point and they help break the chemical bonds in the rock to allow melting.
 - d. Melting resulting from heat transfer from rising magma (heat transfer melting): A rising magma from the mantle brings heat with it that can melt the surrounding rocks at the shallower depths.

PRACTICE (15 MINS)

1. ACTIVITY: Chocolate Mantle Convection

- a. Divide the class into groups of five people each for an activity adapted from the video “Hot Chocolate Mantle Convection Demonstration.” Source: <https://www.youtube.com/watch?v=PdWYBAOqHrk>).
- b. Objective: To illustrate how heat works in the mantle.
- c. Instructions:
 - i. Put water in the pan. Sprinkle it with chocolate powder until the top is thickly covered with dry powder.
 - ii. Slowly put it on the pan holder. Light the candle and place it under the center of the pan.
 - iii. Let it boil for few minutes. Observe what happens.

2. DISCUSSION QUESTIONS

- a. How is heat transferred in the activity? Give evidence for your answer.

Answer: Convection is shown by the presence of mounds and cracks in between the mounds. Radiation is illustrated by the emitted gas directly above the heat source. Conduction is evidenced by the submerging chocolate powder along the rims of the pan.

- b. Describe what happens to the powder when the water starts to boil. Explain why this occurs.

Answer: The chocolate powder starts to rise, forming a conical shape then cracks and emits gas. Slowly, the chocolate powder around it starts to subside and get wet. The heat source is directly beneath this zone so the hotter water is rising in that area. But since the chocolate powder traps the water, the hot water starts to move laterally under the chocolate powder, forming the conical shape, before it manages to create a crater where the water is released as gas.

3. How does this activity relate to the formation of magma?

Answer: The water represents the asthenosphere, the chocolate powder represents the lithosphere and the candles represent heat sources. Magma is formed directly above the heat sources due to relatively higher temperature. Through convection, heat is transferred to other places. And since there are several heat sources, several convection cells develop. Where the colder portions of two convection cells meet, cracks form because the materials are being pulled downwards by the subsiding colder water. These zones represent subduction zones.

Teacher Tip:

Make sure that everybody is wearing proper PPEs and ensure the practice of safety procedures in handling fire and hot objects.

ENRICHMENT

Assignment: A report to be submitted on the next day:

Draw a schematic of a cross section of the earth, showing the different layers of the earth. Include and label (when necessary) the following parts of the illustration:

1. Different tectonic settings where magma is generated
2. The type of melting that is usually associated with the settings identified in # 1
3. Heat transfer mechanisms and the direction of heat transfer (through arrows)

Further research — Below the drawing, note the different zones where magma is formed, and cite one known location of each.

EVALUATION

Summary Questions:

[Easy]

1. What are the two primary sources of the Earth's internal heat?

Answer: Primordial heat and radioactive heat.

2. Cite three tectonic settings where magma is formed.

Answer: mid-oceanic ridges, hot spots and subduction zones

3. What is the role of volatiles in the partial melting of rocks?

Answer: Volatiles help break the chemical bond in rocks, and at the same time, lower the melting temperature of rocks.

[Difficult]

1. What is decompression melting?

Answer: Decompression melting is occurs by reducing the pressure at a constant temperature.

2. How is the Earth's internal heat redistributed?

Answer: Magma transfers the heat from the Earth's interior to the surface when it rises.

3. Describe how rising magma causes melting.

Answer: Rising magma from the mantle brings heat with it which can melt the surrounding rocks at the shallower depths.

	EXCEEDS EXPECTATIONS	MEETS EXPECTATIONS	NEEDS IMPROVEMENT	NOT VISIBLE
Practice Activity	Activity completed on time; authors demonstrate excellent level of understanding of the topic in presenting the answers; correctly answered all questions	Activity completed on time; authors demonstrate acceptable understanding of the topic in answering the question; and answered 2 questions correctly	Activity completed on time; correctly answered 1 question; answers are not presented well	Did not complete the activity and did not answer any of the questions
Enrichment Project	Report submitted on time; report is excellently presented (highly organized flow of discussion); authors demonstrate excellent level of understanding of the topic	Report is submitted on time; report is well-presented (organized flow of discussion with few instances straying from the topic); authors demonstrate acceptable understanding of topic (few corrections and misconceptions)	Report is submitted on time but lacking in substance; report not well presented	Did not submit report on time; report is not complete
Summary questions	Correctly answered all questions	Correctly answered the easy questions and ≤ 3 hard questions	Correctly answered the easy questions	Only ≤ 3 of the easy questions are correctly answered

Lesson 12: Endogenic Processes

Content Standard

The learners demonstrate an understanding of the geologic processes that occur within the Earth. The learners will be able to make a simple map showing places where erosion and landslides may pose risks in the community.

Learning Competencies

The learners will be able to describe what happens after magma is formed **(S11/12ES-Ic-16)** and compare and contrast the formation of the different types of igneous rocks **(S11/12ES-Ic-18)**

Specific Learning Outcomes

At the end of the lesson, the learners will be able to

1. Explain how and why magma rises up,
2. Understand the concept of Bowen's reaction series, and
3. Identify, understand, and explain magmatic differentiation mechanisms operating beneath the surface of the Earth

LESSON OUTLINE

Introduction	Communicating Learning Objectives	5
Motivation	Class Participation	5
Instruction	Magma Properties	35
Practice	Conceptual Mapping	15

Materials

For Practice: Manila paper, cardboards (for flash cards), marking pen, masking tape

For tips on introducing new concepts:

Density difference - a coin, a piece of rock, and a piece of Styrofoam, a glass or pail of water; Viscosity – 1/8 cup of water, oil, honey (or water and sugar thick solution)

Resources

- (1) Monroe, J. S., et al, Physical Geology Exploring the Earth, 6th ed., 2007, pp107-113.
- (2) Carlson, D. H., Plummer, C. C., Hammersley L., Physical Geology Earth Revealed 9thed, 2011, pp289-292.
- (3) Tarbuck, E. J. et al Earth An Introduction to Physical Geology, 2014, pp137-140.
- (4) http://www.colorado.edu/geolsci/courses/GEOL3950/class_notes/Lecture%20%239%20notes%202006.pdf: (Accessed 15Dec 2015).
- (5) <https://wwwf.imperial.ac.uk/earthscienceandengineering/rocklibrary/viewglossrecord.php?glD=00000000159>(Accessed: 14 Dec 2015).
- (6) (<http://www.tulane.edu/~sanelson/eens212/magmadiff.htm>(Accessed 3Dec 2015).
- (7) <http://www.science.marshall.edu/elshazly/Igmet/Differentiation.doc> (Accessed 18 Dec 2015).
- (8) http://www.geology.sdsu.edu/how_volcanoes_work/Controls.html (Accessed 09 Mar 2016).
- (9) http://www.indiana.edu/~geol105/images/gaia_chapter_5/bowen.htm (Accessed 09 Mar 2016).

INTRODUCTION (5 MINS)

Communicate learning objectives

1. Introduce the following learning objectives using the suggested protocols (Verbatim, Own Words, Read-aloud)
 - a. I can identify and explain the different magmatic processes occurring beneath the surface of the Earth.
 - b. I can compare and contrast the formation of the different igneous rock types
2. Review
 - a. Review the different types of igneous rocks based on silica content.
 - b. Review the processes for magma generation and where it is generated. Use the following table to quickly run through these.

Magma Generating Process	Example areas of occurrence
Increase in temperature	Hot spots
Decrease in pressure	Spreading margins
Addition of volatiles	Subduction zones

MOTIVATION (5 MINS)

1. Encourage class participation by asking a question that will guide the students' focus to the topics to be discussed, such as:

What happens to magma after it is formed?

Teacher tips:

The teacher can guide the students by asking some questions that lead to the expected answers.

Example leading questions:

- (1) Do you think magma rises or stays in place?
- (2) What happens to the composition of magma as it rises up?

INSTRUCTION DELIVERY (35 MINS)

1. **Discuss why and how magma rises up** (Monroe et al., Physical Geology, 2007, p107).

Density contrast: magma is less dense than the surrounding country rock. Magma rises faster when the density contrast between the magma and the country rock is greater.

At deeper levels, magma passes through mineral grain boundaries and cracks in the surrounding rock. When enough mass and buoyancy is attained, the overlying surrounding rock is pushed aside as the magma rises. Depending on surrounding pressure and other factors, the magma can be ejected to the Earth's surface or rise at shallower levels underneath.

At shallower levels, magma may no longer rise because its density is almost the same as that of the country rock. The magma starts to accumulate and slowly solidifies (Fig. 2). When the magma solidifies at depth, it can form different types of plutonic bodies.

Viscosity: A measure of a fluid's resistance to flow. Magmas with low viscosity flow more easily than those with high viscosity. Temperature, silica content and volatile content control the viscosity of magma.

Factor	Effect to Viscosity
↑ temperature	↓ viscosity
↑ Silica content (SiO ₂)	↑ viscosity
↑ dissolved water (H ₂ O)	↓ viscosity

Mafic magma is less viscous than silicic (felsic) magma because it is hotter and contains less silica.

Teacher Tips:

To introduce the concept of density difference, the teacher can make a demonstration on how materials of different densities behave when placed in a medium (e.g. water). The teacher can put a coin, a piece of rock, and a piece of Styrofoam on a pail/glass of water, and let the students observe what happens to these materials. A guide question will be: Which materials sink and which ones float? Let the students explain their observation.

To illustrate viscosity, the teacher can make a demonstration using at least three different liquids: honey, oil, water. Using a pan, the teacher can ask a student to pour the liquid on the pan. Ask the students to observe how the different liquids flow (e.g. very fast, fast, slow etc.) on the pan.

2. **Introduce and briefly discuss the Bowen's reaction series** (Carlson, D. H., Plummer, C. C., Hammersley L., Physical Geology Earth Revealed 9th ed., 2011, pp289-290)
- Certain minerals are stable at higher melting temperature and crystallize before those stable at lower temperatures.
 - This series explain how minerals are formed under different temperature conditions, given that all the required elements for certain minerals are present.
 - There are two branches, the discontinuous and continuous branches which happen simultaneously. The minerals in the discontinuous branch include olivine, pyroxene amphibole and biotite mica. In the discontinuous branch, there is only plagioclase, but the Calcium and Sodium content changes from high temperature to low temperature.
 - A single "parental magma" can produce various kinds of igneous rocks through magmatic differentiation.

Discuss the different magmatic differentiation processes.

- Cite only the most common and important processes.
- Magmatic differentiation is the process of creating one or more secondary magmas from single parent magma (Tarbuck, E. J. et al Earth An Introduction to Physical Geology, 2014, p138).
 - Crystal Fractionation** –a chemical process by which the composition of a liquid, such as magma, changes due to crystallization (<https://wwwf.imperial.ac.uk/earthscienceandengineering/rocklibrary/viewglossrecord.php?gID=00000000159>). Common mechanism for crystal fractionation is crystal settling. This means that denser minerals crystallize first and settle down while the lighter minerals crystallize at the latter stages.
 - Partial Melting** - as described in Bowen's reaction series, quartz and muscovite are basically the most stable minerals at the Earth's surface, making them the first ones to melt from the parent rock once exposed in higher temperature and/or pressure. Partial melting of an ultramafic rock in the mantle produces a basaltic magma (Carlson, D. H., Plummer, C. C., Hammersley L., Physical Geology Earth Revealed 9th ed, 2011, p292).
 - Magma mixing** – this may occur when two different magma rises up, with the more buoyant mass overtakes the more slowly rising body. Convective flow then mixes the two magmas, generating a single, intermediate (between the two parent magmas) magma (Tarbuck, E. J. et al Earth An Introduction to Physical Geology, 2014, p139).

3. Discuss the relationship of the different igneous rock types and the environment of formation(http://www.colorado.edu/geolsci/courses/GEOL3950/class_notes/Lecture%20%239%20notes%202006.pdf):
 - a. Basalt and basaltic magma: form when hot rocks in the mantle slowly rise and encounter lower pressures. This leads to decompression melting (melting due to reduced pressures). This commonly occurs along places where plates are moving away from each other (i.e. extensional plate boundaries such as continental rifts and hotspots. This type of magma has low viscosity, low silica, high iron and low volatile (H₂O) contents.
 - b. Rhyolite and rhyolitic magma: formed by either (1) melting of mantle fluxed by water and sediments carried into the mantle in subduction zones; and /or (2) interaction of mantle derived basaltic magmas with continental crust. The magma is highly viscous with relatively high silica, low iron and high volatile (H₂O) contents.
 - c. Andesite and andesitic magma: Andesitic magmas maybe formed in a variety of ways: some are formed when water and sediments on the ocean floor are pushed into the mantle along subduction zones, leading to melting in the mantle. Others are formed when hot basaltic magma interact with continental crust on the way to the Earth's surface, which likewise leads to melting. The silica, iron and volatile (H₂O) contents and viscosity are intermediate between basalt and rhyolite.

PRACTICE (15 MINS)

Conceptual mapping of the Bowen's reaction series.

1. Pre-activity: Before the class starts, the teacher has to prepare two sets of blank diagram of the Bowen's reaction series in a Manila paper, flash cards for the different parameters, minerals and rock types (Refer to the Bowen's reaction series diagram provided in the Instruction delivery section).
2. During the activity: Group the class into two. Give the teams five minutes to paste the flash cards into the diagram in their correct places. Make sure that the students do not refer to their notes and just dwell on how much they learned and understood during the class discussions. Each group to present their answers in front of the class (five minutes each).

Teacher Tip:

The activity may be modified depending on the resourcefulness of the teacher.

ENRICHMENT

A simple report to be submitted on the next day:

Can the same volcano produce volcanic rocks with different compositions? How?

EVALUATION

Summary questions related to the lessons. Questions are classified as described in the table below.

Question format	Type of Question
In regular font	Questions that test whether the student can recall, recognize, define, describe or give examples (knowing).
In bold	Questions that test whether the students understand a concept and apply it in new situations, classify, compare, contrast, relate, use models, interpret information, or explain (applying).
Italicized and bold	Questions that test whether the students can analyze, generalize, integrate, predict, justify, design or draw conclusions (reasoning).

1. Define viscosity.

Answer: Viscosity is the measure of a substance's resistance to flow.

2. Identify the three major factors controlling the viscosity of magma/lava.

Answer: The three major factors controlling the viscosity of magma and/or lava are temperature, silica content and volatile content.

3. Describe how viscosity affects the movement of magma. Compare the viscosity of basaltic and granitic magmas.

Answer: Viscosity is the measure of fluid's resistance to flow. Mafic or basaltic magma, when compared to a felsic or granitic magma is more mobile and flows faster as it is less viscous due to its higher temperature and less silica content. Granitic magma does not reach the Earth's surface as often due to its higher viscosity, but in case, it tends to be thick, slow-moving and can only flow short distances.

4. True or False: Magmatic differentiation is the process of creating one or more secondary magmas from single parent magma.

Answer: True.

5. How does magma change during crystallization?

Answer: Magma becomes progressively more silica-enriched as crystallization progresses.

6. What is the significance of the Bowen's reaction series?

Answer: By knowing the mineral composition of the rock, we can infer based from the Bowen's reaction series the temperature condition in which the rock was formed.

7. What is the Bowen's reaction series?

Answer: Bowen's reaction series describes the sequence of mineral crystallization in a cooling magma. The two branches of the series are the continuous and discontinuous branches. As the temperature drops, the discontinuous branch describes how minerals are

transformed into another type of mineral while the continuous branch shows how calcium-rich plagioclase feldspar is progressively changed into sodic plagioclase. The reverse of Bowen's reaction series describes the melting of rock.

8. Rising magma assimilates crustal rocks but does not result to any change in the composition of the resulting magma. In what condition/s can this occur?

Answer: When the composition of crustal rock and magma are the same, then the composition of a rising magma will not be altered even when assimilation occurs.

9. True or False: The different mechanisms through which crystal fractionation occurs are crystal settling, filter pressing, inward crystallization and flow segregation.

Answer: True.

	1 (NOT VISIBLE)	2 (NEEDS IMPROVEMENT)	3 (MEETS EXPECTATIONS)	4 (EXCEEDS EXPECTATIONS)
Enrichment Project	Did not submit report on time; report is not complete	Report is submitted on time but is lacking of substance; report not well presented	Report is submitted on time; report is well-presented (organized flow of discussion with few instances straying from the topic) authors demonstrate acceptable understanding of topic (few corrections and misconceptions)	Report submitted on time; report is excellently presented (highly organized flow of discussion); authors demonstrate excellent level of understanding of the topic
Summary questions	≤5 of the easy questions are correctly answered	Correctly answered the easy questions	Correctly answered the easy questions and ≤5 hard questions	Correctly answered all questions

Lesson 13: Endogenic Processes

Content Standard

The learners demonstrate an understanding the geologic processes that occur within the Earth.

Learning Competency

The learners shall be able to make a simple map showing places where erosion and landslides may pose risks in the community. The learners will describe the changes in mineral components and texture of rocks due to changes in pressure and temperature **(S11/12ES-Ic-17)**

Specific Learning Outcomes

At the end of the lesson, the learners will be able to

1. Understand the different index minerals used for metamorphic rocks.
2. Understand what causes the metamorphic texture

LESSON OUTLINE

Introduction	Communicating Learning Objectives	3
Motivation	Questions about metamorphism	5
Instruction	Metamorphic minerals and texture	22
Practice	Simulation of fossil distortion	15
Enrichment	After class	

Materials

For the class demonstration: a box of used matchstick or some short lengths of uncooked spaghetti, two rulers, a piece of slate, preferably with color bands from the original bedding (or photograph).

For the practice section: modelling clay, disposable plastic cup (e.g. vending machine coffee cup), stirring rod, a sea shell (e.g. cockle shell), little amount of plaster of Paris (calcium sulfate) or melted candle, water

Resources

- (1) Tarbuck, E.J. et al, Essentials of Geology, 11thed., pp192-193.
- (2) Monroe, J. S., et al, Physical Geology Exploring the Earth, 6th ed., 2007, pp 243-249.
- (3) <http://www.tulane.edu/~sanelson/eens212/metaminerals.htm> (Accessed: 15 Feb 2016).
- (4) <http://www.tulane.edu/~sanelson/eens212/typesmetamorph.htm> (Accessed: 19Feb 2016).
- (5) <http://www.tulane.edu/~sanelson/eens212/metatexture.htm> (Accessed 19 Feb 2016).
- (6) <http://www.rsc.org/education/teachers/resources/jesei/meta/students.htm> (Accessed 21 Feb 2016).
- (7) <http://www.rsc.org/education/teachers/resources/jesei/meta/index.htm>(Accessed 21 Feb 2016).

INTRODUCTION (3 MINS)

Communicate learning objectives

1. Introduce the following learning objectives using the suggested protocols (Verbatim, Own Words, Read-aloud)
 - a. I can describe the changes in mineral components and texture of rocks due to changes in pressure and temperature (metamorphism).
2. Review the rock cycle.
3. Review metamorphic rocks, regional and contact metamorphism

MOTIVATION (5 MINS)

Encourage class participation by asking the students to recall the definition of metamorphic rocks from the previous lesson (S11/12ES-Ib-10). What causes the metamorphism of rocks? What sort of physical and chemical changes in rocks occur during metamorphism?

Teacher Tip:

Heat, pressure, and chemically active fluids are referred to as the "agents of metamorphism". Emphasize that all changes in the rock during metamorphism occur in the solid state (no melting involved).

INSTRUCTION (22 MINS)

1. Discuss the index minerals for metamorphic rocks
 - a. Minerals become unstable and change into another mineral without necessarily a compositional change in response to heat, pressure, and chemically active fluids. Examples include diamond and coal wherein only the mineral structure is affected.
 - b. The mineral composition of the resulting metamorphic rock is influenced by: the mineral composition of the original rock, the composition of fluid phase that was present and the attained pressure and temperature during metamorphism (<http://www.tulane.edu/~sanelson/eens212/metaminerals.htm>).
 - c. Certain minerals identified as index minerals are good indicators of the metamorphic environment or zone of regional metamorphism in which these minerals are formed (Tarbuck, E.J. et al, Essentials of Geology, 11th ed, pp192-193).

Teacher Tips:

- Ask students to recall the Bowen's reaction series - minerals form at definite sequence and at a specific range of conditions (e.g. temperature, pressure).
- In general, the chemical composition of metamorphic rocks does not drastically change during metamorphism.
- Metamorphic grade pertains to the temperature and/or pressure condition(s) to which a rock has been subjected during metamorphism.

2. The typical transition of mineral content resulting from the metamorphism of shale (source: Tarbuck, E.J. et al, Essentials of Geology, 11thed, p192.)
 - a. Fine grained sedimentary rocks (e.g. shale or mudstone) can transform into different metamorphic rocks depending on the degree of metamorphism. At relatively low grade of metamorphism (low temperature and pressure conditions), shale can metamorphose into slate. At a still higher degree of metamorphism, slate can transform into phyllite. (A definite sequence of metamorphic rocks can form with increasing degree of metamorphism). The resulting metamorphic rock type is composed of minerals that are stable at the attained temperature, pressure, and chemical condition of metamorphism.
 - b. Some rocks, however, such as pure quartz sandstone or pure limestone, provide no clue as to the intensity of metamorphism (source: Monroe, J. S., et al, Physical Geology Exploring the Earth, 6th ed., 2007, p249).
3. Discuss the textural changes in rocks that are subjected to metamorphism.
 - a. In general, the grain size of metamorphic rocks tends to increase with the increasing metamorphic grade. With the increasing metamorphic grade, the sheet silicates become unstable and mafic minerals like hornblende and pyroxene start to grow. At the highest grades of metamorphism all of the hydrous minerals and sheet silicates become unstable and thus there are few minerals present that would show a preferred orientation.
 - b. Most metamorphic textures involve foliation which is caused by differential stress. Sheet silicates such as clay minerals, mica and chlorite tend to have a preferred orientation when subjected to differential stress. Slate, phyllite, schist and gneiss are foliated rocks, texturally distinguished from each other by the degree of foliation.
 - c. Differential stress is formed when the pressure applied to a rock at depth is not equal in all directions. Effects of differential stress in the rock's texture if present during metamorphism include (<http://www.tulane.edu/~sanelson/eens212/metatexture.htm>)
 - i. Rounded grains can become flattened in the direction of the maximum compressional stress.
 - ii. Minerals that crystallize or grow in the differential stress field may develop a preferred orientation. Sheet silicates and minerals that have an elongated habit will grow with their sheets or direction of elongation orientated perpendicular to the direction of maximum stress.

Teacher Tip:

Heat, pressure, and chemically active fluids are referred to as the "agents of metamorphism". Emphasize that all changes in the rock during metamorphism occur in the solid state (no melting involved).

Teacher Tips:

- Ask students to recall the Bowen's reaction series - minerals form at definite sequence and at a specific range of conditions (e.g. temperature, pressure).
- In general, the chemical composition of metamorphic rocks does not drastically change during metamorphism.
- Metamorphic grade pertains to the temperature and/or pressure condition(s) to which a rock has been subjected during metamorphism.

- d. Non-foliated metamorphic rock is formed when heat is the main agent of metamorphism. Generally, non-foliated rocks are composed of a mosaic of roughly equidimensional and equigranular minerals.
 - i. Non-foliated metamorphic rocks are generally of two types: those made up of mainly one mineral like quartzite (from medium- to high-grade metamorphism of quartz-rich sandstone) and marble (from low- to high-grade metamorphism of limestone or dolostone), and those in which the different mineral grains are too small for the naked eye, such as hornfels (hornfels if the grain size is small and granulite if the grain size is large such that individual minerals are easily identified with a hand lens).
- e. Demonstration: The activity simulates the formation of slate by the effect of pressure on mudstone or shale (direct copy from Activity 2 <http://www.rsc.org/education/teachers/resources/jesei/meta/students.htm>)
 - i. Instructions:

Pour some used matchsticks, or short pieces of spaghetti onto the bench, so that they lie in all directions. These represent the microscopic, flaky clay minerals in mudstone or shale. Take two rulers and place one on either side of the matchsticks and push the rulers together, trapping the matchsticks and forcing them to line up parallel to the moving rulers.
 - ii. Discussion:

This simulates the formation of slate, where the tiny, flaky clay minerals in a mudstone or shale are made to line up at right angles to the lateral forces.

The slate will split along the planes made by the new minerals more easily than along the original bedding. This property is called rock cleavage (see figure below). You can use the matchsticks / spaghetti to show how such rocks can split along the cleavage by using a ruler to separate the aligned 'minerals'. Simply slide a ruler between the aligned pieces of spaghetti and move them apart. A piece of slate, cut thinly, under the microscope showing the cleavage running from top left to bottom right formed by the aligned minerals

Under conditions of ever-increasing temperatures and pressures, such slates can be metamorphosed into higher-grade metamorphic rock such as schists and ultimately gneisses.

PRACTICE (15 MINS)

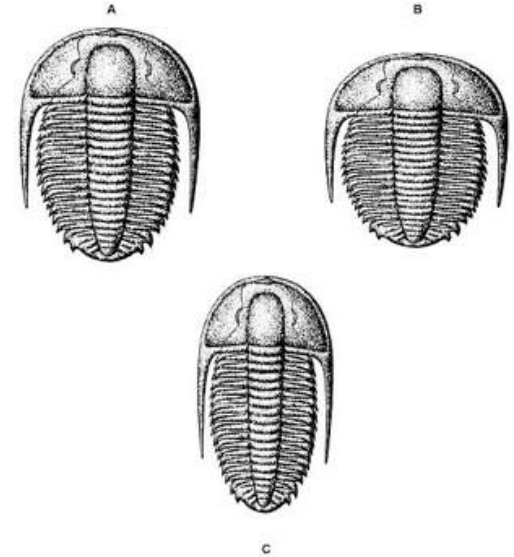
1. Simulation of the distortion of fossils under pressure (direct copy from Activity 3 <http://www.rsc.org/education/teachers/resources/jesei/meta/students.htm>)
2. Many metamorphic rocks, such as slate, are formed deep below ground, under great pressure. They sometimes contain fossils which have been badly squashed. The result of the squashing gives clues about the directions of the pressures which squeezed the rocks.
3. Safety: Wear eye protection when doing the activity. It is the responsibility of the teacher to carry out an appropriate risk assessment.
4. Note: The concept of this activity is also applicable to minerals that are subjected to pressure (metamorphism).
 - a. Instructions:
 - i. Soften the modelling clay.
 - ii. Make a mould by pressing the outside of a shell carefully into the clay. Make a rim around the mould to contain the plaster.
 - iii. Carefully remove the shell, to leave the imprint in the clay.
 - iv. Squeeze the mould so as to change the shape of the shell imprint, by first choosing whether to squeeze it from top to bottom or from side to side. Alternatively, you could push one side up and the opposite side down. This sort of twisting is called shearing. *Whichever you choose, do not distort the shape too much.* Note down how you squeezed the mould, it will be important later.
 - v. Mix up some plaster of Paris in a disposable plastic cup. Place *less than 1 cm* of water in the cup and stir in enough plaster to make a runny cream.
 - vi. Pour the plaster into the distorted mould and leave it for a few minutes to set.
 - vii. Leave any remaining plaster to set in the cup. Wash the stirring rod.
 - viii. When your plaster fossils have set, take your fossil cast out of the modelling clay and then carefully scratch your initials on the base.
 - ix. Pass your fossil on to a nearby group. See if they can work out the directions of the pressures which you used to distort the fossil.
 - x. Do the same for theirs. Did you get it right?
 - b. How could the same distortion have been produced by forces acting in different directions?

Teacher Tip:

The activity may be modified depending on the resourcefulness of the teacher. A melted candle can be used as an alternative for the Plaster of Paris.

Discussion:

1. The fossils (called trilobites) have been distorted compared with fossil A by moderate pressures which have changed the rock in which they were found from a mudstone to a slate.
2. What might have happened to the fossils if the pressures had been much greater?
 - a. In what direction were the forces that squeezed fossil B?
 - b. Estimate by what proportion of its original length it has been squeezed.
 - c. In what direction were the forces that squeezed fossil C?
 - d. Estimate by what proportion of its original length it has been squeezed.
 - e. What do your answers suggest about how much the rock in the region in which the fossils were found has been squeezed?
 - f. How might this scale of deformation have been caused?

**Answers:**

1. The fossils would have been even more distorted, perhaps to the point of being completely destroyed. (Further distortion might have been caused by recrystallization of the rock but students would be unlikely to come up with this unless it had been discussed in class.)
 - a. The forces acted downwards from the top of the paper and upwards from the bottom
 - b. The trilobite has been distorted by about 15-20%.
 - c. The forces acted leftwards from the right of the paper and rightwards from the left
 - d. The trilobite has been distorted by about 15-20%.
 - e. This suggests that the rocks that contain the fossils have been distorted in about the same ratio. The same might well apply to the whole region.
 - f. This could have happened when the rock was at the site of a destructive plate margin.

ENRICHMENT

A simple report to be submitted after three days (or over the weekend):

Explain the relationship of metamorphism and plate tectonics (i.e. expected metamorphic grade in a specific tectonic setting).

EVALUATION

Summary questions related to the lessons:

1. True or false. Chlorite is commonly found in high grade metamorphic rocks
Answer: False. Chlorite is usually associated with low to medium grade metamorphism
2. Other than the attained temperature and pressure during metamorphism, what are the other two factors that control the mineral composition of a metamorphic rock?
Answer: The bulk composition of the precursor rock and the composition of fluid present during metamorphism.
3. Define metamorphism.
Answer: Metamorphism is the recrystallization of minerals in rocks due to a change in pressure and temperature conditions.
4. Define metamorphic grade.
Answer: Metamorphic grade pertains to the temperature and/or pressure condition(s) to which a rock has been subjected during metamorphism.
5. Define foliation.
Answer: Foliation is the pervasive planar structure that results from the nearly parallel alignment of sheet silicate minerals and/or compositional and mineralogical layering in the rock
6. Define the role of stress in the formation of foliation?
Answer: Foliation can occur when a differential stress develops in rocks, wherein, the pressure acting on all sides of the rock is not equal. Rounded grains can become flattened in the direction of the maximum compressional stress. In addition, sheet silicates and minerals that have an elongated habit will grow with their sheets or direction of elongation orientated perpendicular to the direction of maximum stress.
7. True or false: There is a direct correlation between the grain size of metamorphic rocks and the metamorphic grade.
Answer: True
8. Is it possible to find fossils in metamorphic rocks?
Answer: Yes, it is possible to find fossils in metamorphic rocks especially to low-grade metamorphic rocks. The fossils however are expected to be not in the original form due to the effect of the change in temperature and pressure.

Lesson 14: Endogenic Processes

Content Standard

The learners demonstrate an understanding of plate tectonics.

Performance Standard

The learners shall be able to, using maps, diagrams, or models, predict what could happen in the future as the tectonic plates continue to move.

Learning Competencies

The learners shall be able to explain how the continents drift **(S11/12ES-Id-20)**, and cite evidence that support continental drift **(S11/12ES-Id-21)**.

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Discuss the history behind the Theory of Continental Drift;
2. Describe the Continental Drift Theory; and
3. Enumerate and explain the evidence used to support the idea of drifting continents

LESSON OUTLINE

Introduction	Communicating learning objectives	5
Motivation	Discussion	10
Instruction	Lecture/Discussion	50
Practice	Activity: Jigsaw Puzzle	25

Materials

For Motivation section: globe or world map

For Instruction delivery section: internet connection and media player

For Practice section: puzzle print out, scissors, glue, blank paper, pencil, crayons

Resources

- (1) Tarbuck, E.J. et al, Essentials of Geology, 11thed, pp363-367.
- (2) Monroe, J. S., et al, Physical Geology Exploring the Earth, 6th ed., 2007, pp34-41.
- (3) Freudenrich C., Benner, J., Bethel, D. et al, Earth Science CK-12, 2009, pp133-138.
- (4) Carlson, D. H., Plummer, C. C., Hammersley L., Physical Geology Earth Revealed 9th ed., 2011, pp76-81.
- (5) http://www.nuffieldfoundation.org/sites/default/files/files/teacherguidance_continentaldrift.pdf (Accessed: 20 April 2016).
- (6) <https://vimeo.com/14258924> (Accessed: 03 May 2016).
- (7) <http://legacy.earlham.edu/~roosebe/Earlham%20College%20-%20Geology%20211%20-%20Caledonides.htm> (Accessed 27 April 2016).
- (8) <https://earthref.org/ERDA/1541/> (Accessed 20 April 2016).

INTRODUCTION (5 MINS)

Communicating Learning Objectives

1. Introduce the following learning objectives using the suggested protocols (Verbatim, Own Words, Read-aloud)
 - a. discuss the history behind the Theory of Continental Drift;
 - b. describe the Continental Drift Theory;
 - c. enumerate and explain the evidence used to support the idea of drifting continents

MOTIVATION (10 MINS)

1. Present a globe or world map (preferably a big one) and have the students identify the different continents. Ask the students the following questions:
 - a. How much of the Earth is covered by water?
 - b. What are the ocean basins of the world? What is the largest ocean basin?
 - c. Is there anything peculiar with the shape of the continents on opposite sides of the Atlantic Ocean?

Teacher Tip:

See if the students can recognize the remarkable fit between the eastern coast of South America and the western coast of Africa.

INSTRUCTION (50 MINS)

1. Introduce the continental drift hypothesis
 - a. Discuss how the concept of continental drift came about.
 - i. The idea that continents fit together like pieces of a jigsaw puzzle has been around since the 1600s, although little significance was given to it.
 - ii. The continental drift hypothesis was first articulated by Alfred Wegener, a German meteorologist, in 1912. He proposed that a single supercontinent, Pangaea, separated into the current continents and moved across Earth's surface to their present locations. He published his work through a book entitled "The Origin of Continents and Oceans" in 1915.

Note:

- Pangaea – an ancient Greek word meaning "all land" or "entire earth".

- iii. Until the 1950s-60s, it was still widely held that that continents and ocean basins had fixed geographic positions. As such, scientists were reluctant to believe that continents could drift. What was the driving mechanism?
- iv. In the 1960s, the post-war boom in oceanography generated a lot of new data about the ocean floor. It turned out that the ocean floor was not as flat and featureless as they had originally thought. The ocean floor was characterized by deep depressions called trenches and a network of ridges that encircled the globe. These topographic data, together with heat flow measurements, led to the emergence of the Seafloor Spreading Hypothesis which revived interest in Alfred Wegener's idea of drifting continents.

b. Show an animation of continental drift.

- i. The animation is for the students to visually understand how continental drift occurred. One example is the Pangaea Animation by Edgar Salmingo, Source: <https://vimeo.com/14258924>, accessed on 03 May 2016.

Notes:

- Alfred Wegener thought that continents drifted due to the tides formed by the gravitational forces of the Moon and Sun. He also believed that the larger and sturdier continents cut through the thinner oceanic crust, although there is no proof that the ocean floor is weak enough to allow passage of the continents without significantly deforming them in the process.
- There are a lot of animations available online.

2. Perform the Continental Drift Activity (See Practice section)

3. Enumerate and discuss the evidence supporting continental drift

a. **The fit of the continents** - Opponents of Wegener's idea disputed his continental fit evidence, arguing that the fit of the continents' margins was crude, and that shorelines were continuously being modified by wave erosion and depositional processes.

- i. The oceanographic data later on revealed that a much better approach was to fit the continents together along the continental slope, where erosion would be minimal. However, a perfect fit could still not be achieved. The process of stretching and thinning of the continental margins and sedimentary processes (e.g. erosion, delta formation, etc.) could explain some of the overlaps.

b. **Similarity in geologic units and structures** - Wegener discovered that geologic structures (mountain ranges), as well as ages and rock types on opposite sides of the Atlantic Oceans, were identical. For example, the Appalachians of the eastern United States and Canada are similar to the mountain ranges in eastern Greenland, Ireland, Great Britain, and Norway. Wegener concluded that these belonged to a single mountain range that became separated as the continents drifted.

Teacher Tip:

- Several scientists worked on continental drift prior to Wegener but the distinction was awarded to him because of the overwhelming lines of evidence that he presented.

- c. Fossil match** - Similar fossils of extinct plants and animals of the same age were found on different continents which are now separated by oceans. Wegener argued that these organisms physically could not have crossed the oceans because organisms adapt to specific types of environment and their dispersal can be limited by biogeographic boundaries (e.g. oceans, mountain ranges, etc.) A likely explanation for this is that the continents were part of a large contiguous landmass which later on broke apart and drifted.
- i. *Glossopteris flora* (seed fern) – had large seeds (too large to be blown away by wind to different continents) and grew only in subpolar regions, but fossils were widely distributed over Australia, Africa, India and South America (later on discovered in Antarctica).
 - ii. *Mesosaurus* – a freshwater reptile (cannot cross oceans) whose fossils were found only in black shales about 260 million years of age (Permian) in South Africa and Brazil.
 - iii. *Lystrosaurus* and *Cynognathus* – land reptiles whose fossils were found across South America, Africa, India and Antarctica. With their inability to swim and the continent's differing climates, the organisms must have lived side by side and that the lands drifted apart after they became extinct and fossilized.
- d. Glacial and paleoclimate evidence** - A glacier is a slowly moving mass or river of ice formed from the accumulation and compaction of snow on high mountains or in polar areas. As it flows, it carries sediments of different shapes and sizes which are then deposited and slowly compacted into a soft sedimentary rock called till (glacial till). It also creates grooves or scratches called striations in the underlying bedrock.
- i. Wegener analyzed glacial tills and striations of ancient times and found out that glaciers of the same period (late Paleozoic age, around 300 million years ago) were located in Australia, South America, Africa, India and Antarctica. Except for Antarctica, these continents/countries did not have subpolar climate that allowed glaciation. In addition, the striations in the rocks were consistently pointing in different directions. Putting the continents together in accordance to Wegener's Pangaea shows that the glaciation only occurred in a small region in Gondwana (around the South Pole) which then moved outward to the aforementioned continents.

- ii. Reconstructing the location of ancient glaciers led Wegener to discover that the location of the current poles was not the same as the ancient ones. His studies showed that South Africa was originally at the South Pole (300 million years ago), which explains the flow direction of the ancient glaciers. Fitting the continents together places the northern half of Pangaea closer to the tropics and was proven correct by fossil and climatological evidences.

PRACTICE (25 MINS)

Continental Jigsaw Puzzle (modified from Continental Drift Activity (<https://earthref.org/ERDA/1541/>))

Days before the activity: The teacher must be able to print enough copies of the puzzle for all groups.

Instructions:

1. The teacher divides the class into groups of two to five. Each group is provided with activity materials.
2. In the legend, assign different colors for each type of fossil and geologic structure. Use these colors to represent the identified areas within the landmasses.
3. Cut along the borders of the continents using a pair of scissors.
4. On another sheet of paper, place the continent cut-outs and try to reconstruct Pangaea using the given clues (fossils and mountain ranges).
5. When confident of the positions of the continents, glue them on a sheet of paper. Draw a circle around to represent the Earth.
6. Cut out the legend and paste it in the lower portion of the paper.
7. Randomly select few teams to discuss their findings in front of the class.

Discussion:

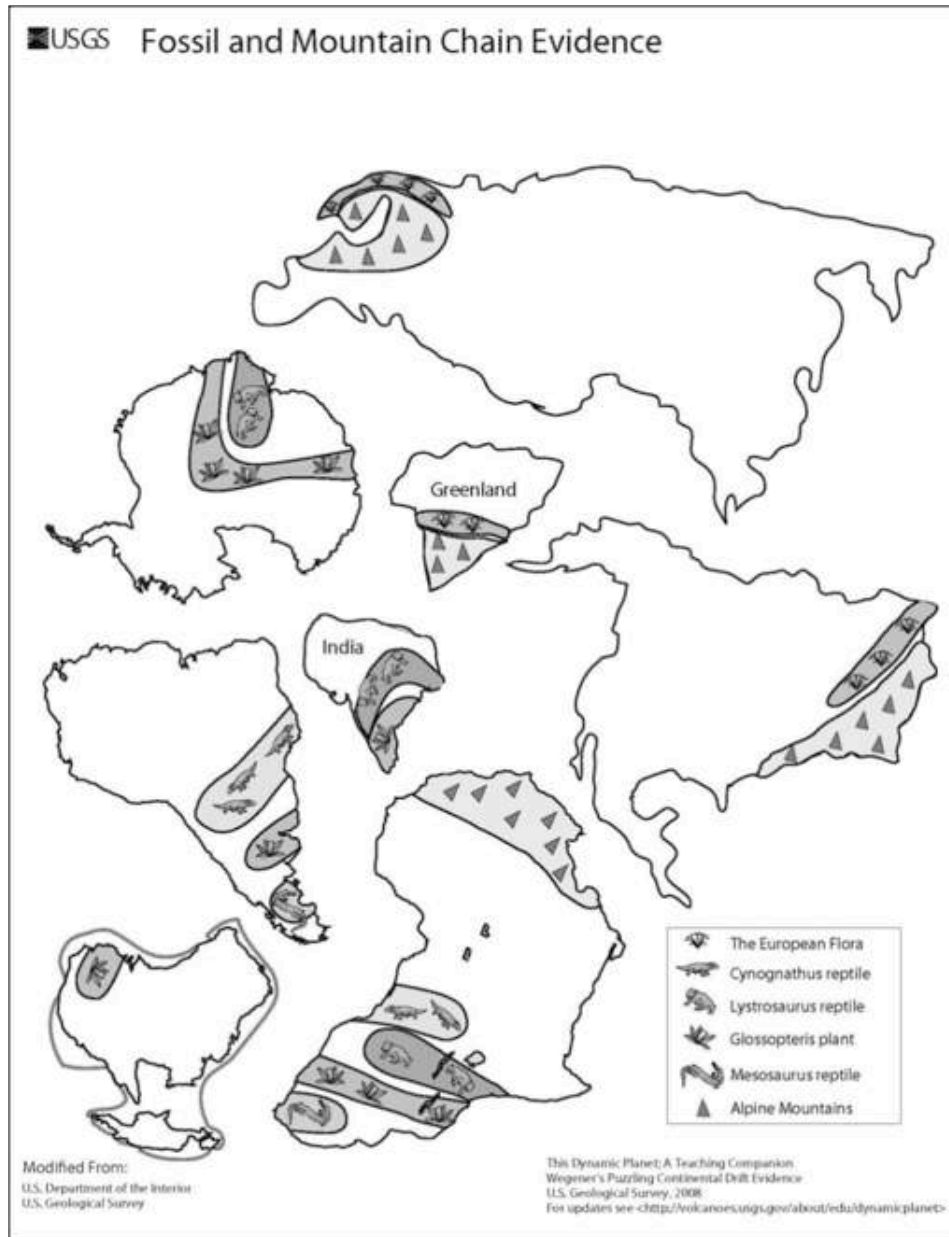
1. What criteria or basis did you consider in piecing together the “jigsaw puzzle”?
2. Look at the resulting map. What can you conclude with regards to the location of the different fossils? What about the mountain range?
3. Give your thoughts on why the cutouts do not perfectly fit with each other.

Teacher Tip

- Expect imperfect fit of the cutouts as these are only approximations of the shapes of the continents after Pangaea split up.

Teacher Tip:

- It is suggested that this discussion portion of the activity will be done after the instruction delivery section. Each student will submit answers as an attachment to their group’s Pangaea puzzle.
- For better resolution, it is suggested that the activity material (left) be downloaded directly from the source.



Source: <http://earthref.org/ERDA/download:1541/> (page 2 of 3).

Answers

1. The basis for piecing together the "jigsaw puzzle" : the shape of coast lines, distribution of fossils and mountain ranges
2. The distribution of fossils and mountain ranges will "line-up" in the reconstructed map (They will form continuous belts or area)
3. The imperfect fit is most likely due to modification of the coastlines resulting from: weathering and erosion, and collisions and movement of plates. Fitting together the continental slopes will provide a much better fit.

ENRICHMENT

To be submitted on the next meeting (modified from https://www.teachengineering.org/collection/cub_/activities/cub_natdis/cub_natdis_lesson02_activity2_worksheetnew.pdf):

Introduction: Other related studies came out after the continental drift hypothesis has been proven and accepted by the scientific community. One of the studies led to the identification of the speed of the continents' movement. Below shows the rate of movement of some of the continents.

Continent	Speed
Antarctic	2 cm/yr
African	2.2 cm/yr
South American	1.5 cm/yr
North American	1.2 cm/yr

Discussion:

1. Compute, in meters, how far these continents will travel in (a) 100 years, (b) 500,000 years and (c) 1 million years. Tabulate the answers.

Answer: Using the formula of velocity/speed, distance is computed as:

$$\text{Distance} = \text{Speed} \times \text{Time}$$

Continent	Speed	Distance Traveled		
		100 years	50,000 years	1 million years
Antarctic	2 cm/yr	2m	1,000m	20,000m
African	2.2 cm/yr	2.2m	1,100m	22,000m
South American	1.5 cm/yr	1.5m	750m	15,000m
North American	1.2 cm/yr	1.2m	600m	12,000m

2. Which continent moves the fastest? Where will it be in 50,000 years?

Answer: The African continent moves the fastest. In 50,000 years, it will be 1.1km away from its current location.

3. Which continent moves the slowest? Where will it be in 1 million years?

Answer: The North American continent is the slowest moving continent with a speed of 1.2cm/yr. In 1 million years, it will be displaced from its current location by 12km.

4. Is there a chance that the continents will collide with each other? Explain your answer. If yes, give an example.

Answer: Yes, continents can collide with each other since they are moving in different directions. India for example has collided and still colliding with the Asian continent. Reconstructing Pangaea shows that India was originally part of the southern half of Pangaea that slowly drifted northwards.

EVALUATION

Summary questions related to the lessons (Questions in regular font are easy questions while the ones in bold are hard):

1. Why do the continents fit roughly along their coastlines?

Answer: Because these were once joined together; they just drifted apart through time.

2. **Define the concept of continental drift.**

Answer: Continental drift is the idea that the continents move. From a single landmass called Pangaea, the continents broke apart and drifted to their current positions.

3. What made early scientists reject Wegener's continental drift idea?

Answer: Although Wegener presented a lot of evidence supporting continental drift, he was not able to convincingly explain how the continents moved.

4. **List the lines of evidence that support continental drift.**

Answer: The evidence of continental drift include (1) continental fit, (2) similarities of geologic units and structures across continents, (3) fossil match across continents, and (4) glacial and paleoclimate evidence.

5. True or False. Mountain ranges on the opposite sides of the Atlantic were used by Wegener to support his continental drift idea.

Answer: True

6. **What evidence can prove that two mountain ranges separated by ocean were part of a single mountain range and that these were once joined together?**

Answer: The mountain ranges should be aligned from one continent to another. The rock types and their ages should be similar for both landmasses. If there are fossils in the area, they should be similar as well.

	1 (NOT VISIBLE)	2 (NEEDS IMPROVEMENT)	3 (MEETS EXPECTATIONS)	4 (EXCEEDS EXPECTATIONS)
Enrichment	Did not submit report; No question was correctly answered	Correctly answered 1-2 question	Correctly answered 3 questions	Correctly answered all questions
Summary questions	Only 2 of the easy questions are correctly answered	Correctly answered the easy questions	Correctly answered the easy questions and 2 hard questions	Correctly answered all questions

Lesson 15: Deformation of the Crust

Content Standard

The learners demonstrate an understanding of plate tectonics.

Performance Standard

The learners shall be able to, using maps, diagrams, or models, predict what could happen in the future as the tectonic plates continue to move.

Learning Competencies

The learners shall be able to explain how the seafloor spreads (**S11/12ES-Id-23**); describe the structure and evolution of ocean basins (**S11/12ES-Id-24**); and explain how the movement of plates leads to the formation of folds and faults (**S11/12ES-Id-22**).

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Discuss the history behind the Theory of Continental Drift;
2. Describe the Continental Drift Theory;
3. Enumerate and explain the evidence used to support the idea of drifting continents;
4. Identify major physiographic features of ocean basins
5. Describe the process of seafloor spreading; and
6. Demonstrate understanding of the theory of plate tectonics and how plate tectonic processes lead to changes in Earth's surface features

LESSON OUTLINE

Introduction	Presentation of objectives and terms	5
Motivation	What if?	10
Instruction	Lecture and discussion	30
Enrichment	Idealized plate boundary map interpretation	15
Evaluation	Pair-up Quiz	15

Materials

Books, unruled paper

Resources

- (1) Tarbuck, E.J., F.K. Lutgens, and Tasa, D. (2014). Earth An Introduction to Physical Geology. Eleventh Edition. Prentice Hall.
- (2) Marshak, Stephen (2013). Essentials of Geology (4th ed.). W.W. Norton.
- (3) <http://www.cosee-se.org/files/southeast/Introduction%20to%20the%20Seafloor%20Teacher.pdf> (Accessed: 27/04/2016)
- (4) http://oceanworld.tamu.edu/resources/ocng_textbook/chapter03/chapter03_04.htm ((Accessed: 27/04/2016)
- (5) Seafloor Spreading Centers: The Life Cycle of the Seafloor Lesson Plan by Ashlee Henig and Stephen Halpern
- (6) <https://earthref.org/SCC/lessons/2011/seafloorspreading/#day4> (Accessed: 26/04/2016)
- (7) <https://opentextbc.ca/geology/chapter/10-3-geological-renaissance-of-the-mid-20th-century/> (Accessed: 25/04/2016)
- (8) <http://www.mrkscience.com/planbook/Earth%20Science/Jan202010/Sea%20Floor%20Spreading%20Made%20Easy-%20Pages%204%205%2010%2011.pdf> (Accessed: 28/04/2016)
- (9) <http://serc.carleton.edu/NAGTWorkshops/intro/activities/65696.html> (Accessed: 20/04/2016)
- (10) <http://serc.carleton.edu/NAGTWorkshops/intro/activities/25297.html> (Accessed: 20/04/2016)

INTRODUCTION (5 MINS)

1. Introduce the following learning objectives and important terms
 - a. I can identify major physiographic features of ocean basins
 - b. I can describe the process of seafloor spreading
 - c. I can demonstrate an understanding of the theory of plate tectonics and how plate tectonic processes lead to changes in Earth's surface features
2. Introduce the list of important terms that learners will encounter.
 - a. Mid-ocean ridges
 - b. Abyssal plains
 - c. Trench
 - d. Passive margin
 - e. Continental drift
 - f. Seafloor spreading
 - g. Lithosphere
 - h. Asthenosphere
 - i. Magnetic anomaly
 - j. Plate tectonics
 - k. Plate boundary
 - l. Subduction
 - m. Island arc
 - n. Transform fault
3. Have students define in their own words what they know of the terms. Write their responses on the board. Leave student responses up and refer to these throughout the lesson.

MOTIVATION (10 MINS)

Connect the lesson to a real-life problem or question.

1. Ask students: What would the ocean floor look like if we drain away all the seawater? Instruct students to sketch a picture of what they think the ocean bottom may look like.

2. Have the students compare their sketches with their classmates.
3. Show students a topographic map of the Earth (attached with this teaching guide or may be downloaded at http://d32ogoqmya1dw8.cloudfront.net/images/NAGTWorkshops/structure/SGT2012/activities/noaa_global_topographic_map.jpg)
4. Ask students to locate the continents and identify arcuate and linear features on the continents (ex. Major mountain chains like Andes and Himalayas; linear lakes in Africa)
5. Help students identify the major ocean basins: Pacific, Atlantic, Indian, Arctic.
6. Ask students to describe the ocean floor. (Probable answers: The seafloor is not flat!; Seafloor topography is as varied and rugged as that on land; Middle of the seafloor is not the deepest part.) As with the continents ask them to point on the map arcuate and linear features on the ocean floor (ex. seamount chains, volcanic islands, mid-oceanic ridge, trenches).
7. Ask students to locate Iceland. What feature in the Atlantic Ocean can be observed slicing through Iceland? (The mid-Atlantic ridge, an example of an underwater mountain range. It is a part of the most extensive chain of mountains that wraps around the globe for more than 65,000 km!)
8. Explain to students that prior to the 1940s, very little was known about the deep oceans. During the WWII, with the advances in electronics and sonar, it became technologically possible to map the ocean floor in great detail. This provided the databases to construct the first detailed maps of the important features of the ocean floor such as mid-oceanic ridges and trenches.

Teacher Tip:

Encourage all students to participate. If a student finds a feature, ask him to point to the map and trace it with his finger to ensure that everybody in class could identify the feature.

INSTRUCTION (30 MINS)

Give a demonstration/lecture/simulation

SEAFLOOR BATHYMETRY

1. Briefly discuss the various methods of measuring ocean depths
 - a. **Sounding line** – weighted rope lowered overboard until it touched the ocean bottom; this old method is time-consuming and inaccurate
 - b. **Echo sounding**– type of sonar which measures depth by emitting a burst of high frequency sound and listening for the echo from the seafloor. Sound is emitted from a source on the ship and the returning echo is detected by a receiver on the ship. Deeper water means longer time for the echo to return to the receiver.
- b.

- a. **Satellite altimetry** – profiles the shape of the sea surface by measuring the travel time of a radar pulse from the satellite to the ocean surface and back to the satellite receiver. The shape of the sea surface approximates the shape of the sea floor.
3. Describe the different features of the ocean floor
 - a. **Continental margin** – submerged outer edge of the continent where continental crust transitions into oceanic crust
 - i. Passive or Atlantic type – features a wide, gently sloping continental shelf (50-200m depth), a steeper continental slope (3000-4000m depth), and a flatter continental rise.
 - ii. Active or Pacific type – characterized by a narrow shelf and slope that descends into a trench or trough
 - b. **Abyssal plains and abyssal hills** – abyssal plain is an extremely flat, sediment-covered stretches of the ocean floor, interrupted by occasional volcanoes, mostly extinct, called seamounts. Abyssal hills are elongate hills, typically 50-300m high and common on the slopes of mid oceanic ridge (Note: figure above is not a very good representation of abyssal hill). These hills have their origins as faulted and tilted blocks of oceanic crust.
 - c. **Mid-ocean ridges** – a submarine mountain chain that winds for more than 65,000 km around the globe. It has a central rift valley and rugged topography on its flanks. Mid-ocean ridges are cut and offset at many places by transform faults. The trace of a transform fault may extend away from either side of the ridge as a fracture zone which is older and seismically inactive.
 - d. **Deep-ocean trenches** – narrow, elongated depressions on the seafloor many of which are adjacent to arcs of island with active volcanoes; deepest features of the seafloor.
 - e. **Seamounts and volcanic islands** – submerged volcanoes are called seamounts while those that rise above the ocean surface are called volcanic islands. These features may be isolated or found in clusters or chains.

Teacher Tip:

Some common misconceptions that can be addressed in this lesson:

- The seafloor is flat or bowl-shaped and the deepest portion is in the middle.
- The seafloor is the same age as the continents.
- The entire seafloor is the same age
- The Earth is expanding; seafloor is created but never destroyed.
- Continents drift through the ocean and oceanic currents are responsible for continental drift.
- "Plate" is synonymous to "continent".
- (Source: <https://earthref.org/SCC/lessons/2011/seafloorspreading/#day2>)
- Discuss with students these statements and explain why these statements are false.

SEAFLOOR SPREADING

1. Review of Continental drift theory
 - a. Remind students of the evidences for Continental drift:
 - i. Fit of the continents
 - ii. Matching of rock units across ocean basins
 - iii. Distribution of fossils

- iv. Paleoclimate evidence (evidence of tropical climates and past glaciations)
- b. Briefly discuss why many scientists rejected Wegener's Continental drift.
 - i. Wegener could not conceive of an acceptable mechanism for moving the continents around.
- 2. Enumerate the different observations/evidences that led to the proposal of seafloor spreading by Hess
 - a. Distribution of seafloor topographic features – distribution of mid-ocean ridges and depth of the seafloor
 - b. Sediment thickness – fine layer of sediment covering much of the seafloor becomes progressively thicker away from mid-ocean ridge axis; seafloor sediment not as thick as previously thought
 - c. Composition of oceanic crust – consists primarily of basalt
 - d. High heat flow along mid-ocean ridge axes – led scientists to speculate that magma is rising into the crust just below the mid-ocean ridge axis
 - e. Distribution of submarine earthquakes – earthquakes do not occur randomly but define distinct belts (earthquake belts follow trenches, mid-oceanic ridges, transform faults).
- 3. Describe the seafloor spreading hypothesis. Discuss the different lines of evidence for seafloor spreading
 - a. Seafloor spreading hypothesis

In 1960, Harry Hess advanced the theory of seafloor spreading. Hess proposed that seafloor separates at mid-ocean ridges where new crust forms by upwelling magma. Newly formed oceanic crust moves laterally away from the ridge with the motion like that of a conveyor belt. Old oceanic crusts are dragged down at the trenches and re-incorporated back into the mantle. The process is driven by mantle convection currents rising at the ridges and descending at the trenches. This idea is basically the same as that proposed by Arthur Holmes in 1920.
 - b. Proof for seafloor spreading

Magnetic stripes on the seafloor: detailed mapping of magnetism recorded in rocks of the seafloor shows that these rocks recorded reversals in direction and strength of the Earth's magnetic field. Alternating high and low magnetic anomalies run parallel to mid ocean ridges.

Teacher Tip:

Point out that these arguments for continental drift can also be evidences to support seafloor spreading. The continents were once joined together but now separated. This implies that something had to be put between the continents for them to move apart.

Pattern of magnetic anomalies also matches the pattern of magnetic reversal already known from studies of continental lava flows. Deep sea drilling results: Age of seafloor forms a symmetric pattern across the mid-oceanic ridges, age increases with distance from the oceanic ridge; no seafloor older than 200 million years could be found, indicating that seafloor is constantly being created and destroyed.

Seafloor spreading demonstration

1. For this demonstration, the class will need 4 books, 4 identical strips of unlined paper, 2 different colored markers or crayons. Place two books on the table with the spines almost touching. Have a student take 2 strips of paper and insert them back to back into the gap between the books. Make sure the ends of the paper strips are sticking up. Repeat this setup adjacent to the first two books but offset the center of the second setup slightly to the right.
2. Assign one student per setup to pull on the edges of the paper strips evenly on opposite directions while the class observes. While two students very slowly pull out the paper strips at the same rate, have one student use a marker or crayon to mark across the paper strips where they exit the gap. This will create a stripe of color along the gap that grows wider as more paper is pulled out. Explain that this color represents the rocks with normal polarity, that is, the rocks cooled and solidified when Earth's magnetic polarity is similar to what we have today.
3. Afterwards, announce that a magnetic reversal has occurred, that is, the magnetic polarity has flipped or is now oriented in the opposite direction. At the same time, the student takes the other colored marker/crayon and begins coloring the paper strip along the gap. Continue switching polarity but vary the timing between each switch so that each setup will result in two strips of paper that are mirror image of each other with alternating stripes of color of varying widths. When the entire length of the paper strips are pulled out, ask students to tape together the paper strips down at the center where the last stripes are.

Demo Questions

1. Ask students to identify the following:
 - a. Spreading center/mid ocean ridge
 - b. Strips with normal polarity and strips with reversed polarity
 - c. Where the oldest and youngest rocks are
2. How does this activity model seafloor spreading?

Teacher Tip:

Review with students the concept of mineral magnetism. Point out that ferromagnetic minerals within partially molten rock can align with the ambient magnetic field. But why do these minerals do not realign themselves when the next magnetic reversal occurs? When rocks cool below the Curie temperature (around 500°C), the minerals retain the direction of magnetization. Thus, unless the magnetized rock is heated beyond the Curie temperature, it will retain its original magnetism.

Answers to Demo Questions:

1. (a) the center where the two strips are held together
(b) Normal polarity, stripes of one color (e.g. blue); reverse polarity, stripes of another color (e.g. orange)
(c) youngest rocks are along the spreading center on both sides, oldest rocks are on the outer edges of the paper strip

Theory of Plate Tectonics

1. Outline the main principles Plate Tectonics
 - A. The Earth's outermost rigid layer (lithosphere) is broken into discrete plates each moving more or less as a unit.
 - B. Driven by mantle convection, the lithospheric plates ride over the soft, ductile asthenosphere.
 - C. Different types of relative motion and different types of lithosphere at plate boundaries create a distinctive sets of geologic features.
2. Review the concept of lithospheric plate
 - A. The lithosphere consists of the crust and the uppermost mantle.
 - Average thickness of continental lithosphere :150km
 - Average thickness of old oceanic lithosphere: 100km
 - B. Composition of both continental and oceanic crusts affect their respective densities.
 - C. The lithosphere floats on a soft, plastic layer called asthenosphere.
 - D. Most plates contain both oceanic and continental crust; a few contain only oceanic crust.
 - E. A plate is not the same as a continent.
 - Identify and describe the three types of plate boundaries

Teacher Tip:

The paper strips represent the oceanic crust created at the mid ocean ridge. The newly formed oceanic crust "spreads" laterally. The alternating stripes represent the episodes of magnetic reversals. It is important to note that the mirror image implies that the rocks on either side of the spreading center are formed at the same time. (This model, however, does not account for the destruction of old oceanic crust at trenches.)

Using a white board or transparency film (if using overhead projector) get students to draw with you the different features associated with each type of plate boundary. This will help students easily visualize shapes, motion, and spatial relationships related to the plate boundaries.

TYPES OF PLATE BOUNDARIES				
Plate Boundary		Plate movement	Description	Example
Divergent	Oceanic-Oceanic	Plates moving away from each other	Forms elevated ridge with rift valley at the center; submarine volcanism and shallow earthquakes	Mid-Atlantic ridge; East Pacific rise
	Continental-Continental		Broad elevated region with major rift valley; abundant volcanism and shallow earthquakes	East African Rift valley; Red Sea
Convergent	Oceanic-Continental	Plates moving toward each other	Dense oceanic plate slips beneath less dense continental plate; trench forms on the subducting plate side and extensive volcanism on the overriding continental plate; earthquake foci becoming deeper in the direction of subduction	Western South America
	Oceanic-Oceanic		Older, cooler, denser plate slips beneath less dense plate; trench forms on subducting plate side and island arc on overriding plate; band of earthquakes becoming deeper in the direction of subduction	Aleutians; Marianas
	Continental-Continental		Neither mass is subducted; plate edges are compressed, folded, and uplifted resulting in the formation of major mountain range	Himalayas; Alps
Transform		Plate sliding past each other	Lithosphere is neither created nor destroyed; most offset oceanic ridge systems while some cut through continental crust; characterized by shallow earthquakes	mid-ocean ridge; San Andreas fault

Briefly discuss the Wilson Cycle

1. Plate tectonics is cyclic. In 1966, J. Tuzo Wilson proposed a cycle that includes continental break-up, drifting, collision and re-assembly of the continent.
2. Main phases of the Wilson Cycle
 - a. Rifting within the supercontinent leads to the opening of new ocean basin and formation of oceanic crust.
 - b. Passive margin cools and sinks, and sediment accumulates along the edge.
 - c. Convergence begins, initiating subduction and eventual ocean closure.
 - d. Continent-continent collision forms the next supercontinent.
3. Explain the driving forces for plate motion
 - a. Convection in the mantle (the sinking of denser material and rising of hot, less dense material) appears to drive plate motion.
 - b. Gravity-driven mechanisms such as slab-pull and ridge-push are thought to be important in driving plate motion. Slab-pull develops when cold, dense subducting slab of lithosphere pulls along the rest of the plate behind it. Ridge-push develops as gravity pushes the lithosphere off the mid-ocean ridges and toward the subduction trenches.

ENRICHMENT (15 MINS)

Idealized Plate Boundary Map and Cross Section

1. Refer to the hypothetical plate map below showing continents A and B separated by an ocean. Answer the following questions:
 - a. How many plate portions are shown?
 - b. Draw arrows on the map to show the relative direction the plates are moving.
 - c. Draw a triangle (Δ) where volcanic activity is likely to occur.
 - d. Draw a circle (o) where earthquake is likely to occur.
 - e. Indicate with an arrow the younging direction of the lithosphere.
 - f. Mark the location and type of each plate boundary shown in the map.
 - g. If the ocean is opening at a rate of 3cm/yr, how wide will the ocean be in 100 million yrs? Give your answer in kilometers.

Answers:

- Black arrows indicate direction of movement of plates; large red arrows indicate younging direction of the oceanic lithosphere; white circles and red triangles represent location of earthquakes and volcanoes
- Mid-ocean ridge represents a divergent plate boundary (boundary between plates 1 and 2); saw teeth pattern represents a subduction zone which is a convergent type of plate boundary (boundary between plates 2 and 3)
- Volcanism and seismicity are associated with plate boundaries
- At 3 cm/yr spreading rate, ocean basin would be 3,000 km wider in 100 million years (assuming subduction continues along the boundary between plates 2 and 3 and that no subduction is developed within plate 1)

EVALUATION (15 MINS)

1. Have each student formulate 3 review questions that cover the content of the lesson. Break the class into pairs and instruct students that they will quiz their partners with the questions they have prepared and discuss between them the answers. Each pair should submit their questions and corresponding answers.

	1 (NOT VISIBLE)	2 (NEEDS IMPROVEMENT)	3 (MEETS EXPECTATIONS)	4 (EXCEEDS EXPECTATIONS)
Idealized Plate Boundary Map 1. Questions are answered accurately 2. Map is properly labelled				
Question and Answer 1. Questions are pertinent to the topic and stimulate thought and inquiry. The questions encourage students to evaluate and analyze in order to arrive at an answer. 2. Answer is accurate and complete. Response is correct and demonstrate understanding of concepts.				

Seafloor Spreading Demonstration Instructions

1. Prepare the materials.
2. Set up the book and insert paper strips back to back along the gap between the books.
3. Pull on the edges of the paper strips in opposite directions. Use a crayon or marker to mark across the gap as the strips are being pulled out slowly.
4. Announce magnetic reversal and at the same time a student takes a different colored crayon/marker and begins marking along the gap. Continue switching polarity but vary the timing between each switch until all the paper has been pulled out.

Lesson 16: History of the Earth

Content Standard

The learners demonstrate an understanding of how the planet Earth evolved in the last 4.6 billion years (including the age of the Earth, major geologic time subdivisions, and marker fossils).

Learning Competencies

The learners shall be able to explain how relative and absolute dating were used to determine the subdivisions of geologic time (**S11/12ES-1e-27**); and describe how marker fossils (also known as guide fossils) are used to define and identify subdivisions of the geologic time scale (**S11/12ES-1e-28**).

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Acquire familiarity with the Geologic Time Scale;
2. Show the contributions of different personalities in the establishment of the Geologic Time Scale;
3. Describe how relative and absolute dating were used to subdivide geologic time; and
4. Explain how fossils have been used to define and identify subdivision of the geologic time scale

LESSON OUTLINE

Introduction	Presentation of objectives and terms	5
Motivation	Means, motive, and opportunity	10
Instruction	Lecture proper and discussion	45
Enrichment	Index fossils of the Philippines	

Materials

Manila paper or projector, several sets of cards/ print outs of fossil foraminifera assemblages

Resources

- (1) Carlson, D.H., Carlson, Plummer, C.C., and Hammersley, L., 2011. Physical Geology: Earth Revealed. McGraw-Hill. 645 p. Desonie, D., 2015. CK-12 Earth Science High School . <http://www.ck12.org/earth-science/>
- (2) Junine, J.I., 2013. Earth Evolution of a Habitable World. Second Edition. Cambridge University Press. 304 p. Kirkland, K. 2010. Earth Science: notable research and discoveries. Facts on File, Inc., 212 p.
- (3) Lutgens, F.K., Tarbuck, E.J. and Tassa, D., 2013. Essentials of Geology. 11th Edition. Pearson Prentice Hall, 554 p. Tarbuck, E.J. and Lutgens, F.K., 2008. Earth – An Introduction to Physical Geology. 9th Edition Pearson Prentice Hall, 703 p.

PRE- CLASS PREPARATION

1. Write the Geologic Time Scale on the board or use Manila Paper
2. Prepare several sets of (paper or cardboard print-outs) of fossil foraminifer cards (http://216.166.82.105/sites/default/files/Faunal_Succession/Foraminifera_Cards.pdf)

Teacher Tip:

Teacher can also use a projector if available.

INTRODUCTION (5 MINS)

1. Introduce the following learning objectives :
 - a. Acquire familiarity with the Geologic Time Scale;
 - b. Show the contributions of different personalities in the establishment of the Geologic Time Scale;
 - c. Describe how relative and absolute dating were used to subdivide geologic time;
 - d. Explain how fossils have been used to define and identify subdivision of the geologic time scale
2. Introduce or review the definition of the following terms:
 - a. Fossils
 - b. Relative vs Absolute Dating
 - c. Stratigraphy

MOTIVATION (10 MINS)

1. Ask the students if they like watching criminal investigation/detective work themed TV shows. Ask the students to name their favorite show. In evaluating a suspect of a crime, investigators need to establish **means** (ability to commit the crime), **motive** (reason for the crime) and **opportunity** (chance to do the crime). In trying to evaluate opportunity, it often important to determine the sequence of events or the **time-line** (exact time events have occurred).
2. In investigating the history of the Earth, it similarly to important to establish chronology - events in order of occurrence in time. The geologic timescale is used by scientist to describe timing and relationship between past events in Earth's history.
3. What killed the Dinosaurs? Evaluate your "suspects" in terms of means and opportunity!

Teacher Tips:

Inform students that Dinosaurs are but one of a large group of organisms (both on land and at sea) that became extinct during this mass extinction event. (The proposed cause should be capable of world wide destruction). Possible answers include asteroid impact, volcanic eruption, climate change, disease, etc.)

Inform the students that scientists believe that the mass extinction event that wiped out the dinosaurs occurred around 65 millions of years ago.

INSTRUCTION/ DELIVERY/ PRACTICE (45 MINS)

Age of the Earth

- The Earth has a very long history — 4.6 billions of years of history.
- The age of the Earth is based from the radioactive isotopic dating of meteorites.
- The oldest dated rock from the Earth is only ~3.8 billion years old. Why?

Rocks and Fossils

- The history of the Earth is recorded in rocks but the rock record is inherently incomplete. Some of the "events" do not leave a record or are not preserved. Some of the rock record may have also been lost through the recycling of rocks (Recall the rock cycle)
- Preserved in rocks are the remains and traces of plants and animals that have lived and died through-out Earth's History — fossils. The fossil record provides scientists with one of the most compelling evidence for Charles Darwin's Theory of Evolution. (increasing complexity of life through time).

Rocks, Fossils and the Geologic Time Scale

- The Geologic Time Scale – the time line of the History of the Earth, is based from the rock record.
- Geologic time is subdivided into hierarchal intervals, the largest being Eon, followed by Era, Period, and Epoch, respectively. Subdivision of Geologic time is based from significant events in the Earth's History as interpreted from the rock record.
- The mass extinction event which lead to the extinction of the dinosaurs occurred around 66.4 million years ago marks the boundary between the Mesozoic Era (Age of the Reptiles) and the Cenozoic Era (Age of Mammals). This mass extinction event may have been pivotal in the rise in dominance of the mammals during the Cenozoic Era.
- Complete the information in the table below.
- Create a Pie Chart to represent the percentage of each division of time in Table 2 with respect to the Geologic Time Scale.

Teacher Tips:

- Meteorites represent primitive and undifferentiated (unaltered) solar system material.
- The Earth differentiated or separated into the crust, mantle, and the core. Dating the Earth's crust provides the age of the crust and not necessarily the whole Earth.
- The rock record is not a video documentary of Earth's History. A large amount of analysis and interpretation is required to extract information from rocks.
- The oldest known fossils are simple single celled organisms found in rocks that are 3.8 billion years old. The first multi-cellular organism evolved around 600 millions years ago.
- Introduce the Geologic Time Scale by presenting table 1. A more detailed discussion of the Geologic Time Scale in relation to Earth's History will be given in the next lesson.
- This activity will help the students get familiar with the subdivisions of the Geologic Time Scale.
- Check if students are able to calculate percentages and are able to present their data in the form of a pie chart.

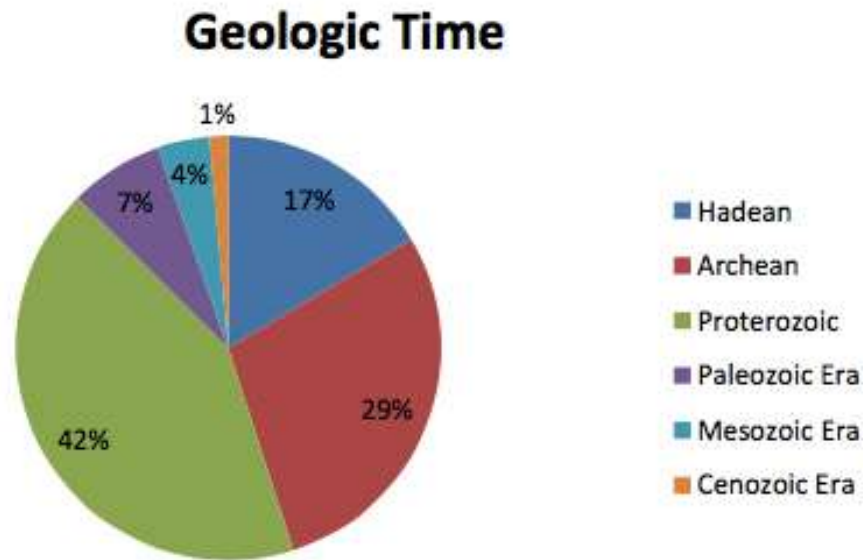
Relative Proportion of the Major Subdivisions of Geologic Time.

DIVISIONS OF GEOLOGIC TIME		TIME INTERVAL (in millions of years)	DURATION (in millions of years)	% of Geologic Time
Cenozoic Era				
Mesozoic Era				
Paleozoic Era				
Pre-Cambrian	Proterozoic			
	Archean			
	Hadean			

With response:

DIVISIONS OF GEOLOGIC TIME		TIME INTERVAL (in millions of years)	DURATION (in millions of years)	% of Geologic Time
Cenozoic Era		<i>66.4 - present</i>	<i>66.4</i>	<i>1.46</i>
Mesozoic Era		<i>245 - 66.4</i>	<i>178.6</i>	<i>3.93</i>
Paleozoic Era		<i>570 - 245</i>	<i>325</i>	<i>7.14</i>
Pre-Cambrian	Proterozoic	<i>2500 - 570</i>	<i>1930</i>	<i>42.42</i>
	Archean	<i>3800 - 2500</i>	<i>1300</i>	<i>28.57</i>
	Hadean	<i>4550 - 3800</i>	<i>750</i>	<i>16.48</i>

Pie Chart showing relative proportion of the major subdivisions of Geologic Time.



- a. One of the first to recognize the correspondence of between rocks and time is Nicholas Steno (1638-1686). Steno's principles – superposition, original horizontality, and lateral continuity became the foundation of stratigraphy – the study of layered rocks.
- b. Since the Geologic Time Scale is based on the rock record, the first order of business is to establish the correct succession of rocks. Initially, this was done using relative dating techniques.
- c. One of the earliest attempts to subdivide the rock record into units of time was made by Abraham Gottlob Werner, a German geologist. Werner divided the rock record into the following rock-time units (from oldest to youngest): Primary, Secondary, Tertiary, and Quaternary. Werner used the Principle of Superposition extensively to establish temporal relationship among the rock units.
- d. Fossils are also useful in determining relative ages of rocks. William "Strata" Smith (1769 – 1839), while working in a coal mine, observed that each layer or strata of sedimentary rock contain a distinct assemblage of fossils which can be used to establish equivalence (correlation) between rock units separated by long distances. Moreover, he observed that these fossils succeed each other vertically in a definite order.

Teacher Tips:

- Using the Pie Chart, point out that the Pre- Cambrian (Hadean, Archean, and Proterozoic) represents a disproportionately large part of the Geologic Time (> 87 %), yet we know very little of what happened during the Pre-Cambrian! (incomplete/imperfect rock record)
- Call on students to define the principles of superposition, cross-cutting relationship, inclusion, and unconformities (previous lesson (S11/12ES-Ie-26)
- Abraham Werner is (1749 – 1817) is considered to be the father of German Geology. He is also the proponent of "Neptunism" – the idea that all of the Earth's rocks formed from an all encompassing ocean. (now a discarded theory used to interpret the history of the Earth).
- Tertiary Period – part of the Cenozoic Era, from 66.4 to 1.5 millions of years ago
- Younger layers will contain a greater proportion of fossils with living representatives.

- e. Whereas William Smith used fossils primarily to identify rock layers, Charles Lyell (1797 – 1875), British Lawyer and Geologist, recognized the utility of fossils in subdividing Geologic Time on the basis of fossils. He was able to subdivide the Tertiary by examining the proportion of living vs. extinct fossils in the rocks.
- f. The underlying reason for this definite and orderly succession of fossils in the rock record is organic evolution.

EVOLUTION OF EARTH'S HISTORY

- a. Fossils are an essential part of subdividing the Geologic Time.
- b. Biostratigraphy - a sub-discipline of stratigraphy which deals with the use of fossils in correlation and establishing the relative ages of rocks.
- c. Index Fossils - are marker fossils used to define periods of Geologic Time. Ideally, index fossils are distinctive (can be easily identified and distinguished from other fossils, widespread (distribution is not confined to a few locality) , and have limited geologic time range.
- d. Ultimately, the Geologic Time Scale was assigned numerical dates (absolute dating) through the radiometric dating of rocks.

Activity: Stratigraphy and Evolution: Using Fossils to Tell "Deep Time"

(Olson, H.C. 2011. Stratigraphy and Evolution: Using Fossils to Tell "Deep Time," TXESS Revolution <http://www.txessrevolution.org/FaunalSuccession> Accessed 01/05/16)

- a. Divide class into groups of 3 – 5 students.
- b. Provide each group set of cards/print-outs representing fossil assemblages from different rock layers.
- c. Explain to the students that the actual size of the fossils represented in the illustrations is much smaller. Foraminifera are mostly marine microscopic, single celled organisms that have calcareous shells. When the organism dies, the shells or tests become part of the sediment record. Foraminifers are important index fossils — abundant, widespread, distinctive, and have relatively limited geologic time range.
- d. Ask each group to arrange the cards in order from oldest to youngest.
- e. Ask the students to do research on the index fossils of the Philippines. Name at least one index fossil, Indicate what division of the Geologic Time Scale the index fossil represents and where the index fossil have been reported.

- If your school is near a coast, you can collect beach sand and examine them using a binocular microscope. Chances are you will see specimens of Foraminifers in the sediments. Get the students to see actual specimens of Foraminifers
- Students are to apply the Principle of Faunal Succession to be able to arrange the cards/assemblage of fossils from oldest to youngest.
- While the students are arranging their stack of cards, the teacher goes around and asks the students their reason/s for their arrangement of the cards.



Foraminiferal fossil assemblages from a stratigraphic section. (images after Jones, D.J., 1956, Introduction to Microfossils, Harper, 406 p.)

EVALUATION				
	1 (NOT VISIBLE)	2 (NEEDS IMPROVEMENT)	3 (MEETS EXPECTATIONS)	4 (EXCEEDS EXPECTATIONS)
Student can enumerate the major subdivisions of the Geologic Time Scale.				
Student correctly calculates and presents in a Pie Chart the relative percentages of the major subdivisions of the Geologic Time Scale.				
Student can explain how relative and absolute dating techniques were used to establish the Geologic Time Scale.				
Students can describe the historical development of the subdivision of Geologic Time and the contribution of important personalities.				
Students are able to define marker or index fossils.				
Students can explain the Principle of Faunal Succession				
Students can explain the underlying reason why there is a definite and determinable succession of fossils in the rock record.				
Students are able to apply the Principle of Faunal Succession for relative dating of stratigraphic sequences.				

Lesson 17: History of the Earth

Content Standard

The learners demonstrate an understanding of how the planet Earth evolved in the last 4.6 billion years (including the age of the Earth, major geologic time subdivisions, and marker fossils).

Learning Competency

The learners shall be able to describe how the Earth's history can be interpreted from the geologic time scale **(S11/12ES-le-29)**

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Appreciate the immensity of geologic time and recognize that the Earth has a very long history;
2. Identify the timing and duration of the major events in Earth's History;
3. Recognize how short human history is in relation to the history of the Earth

LESSON OUTLINE

Introduction	Presentation of objectives and terms	5
Motivation	History of the Earth	10
Instruction	Lecture proper and discussion	45
Enrichment	Essay	25

Materials

5 – 10 m measuring tape, Masking Tape, Marking Pens/Colored Chalk, Significant Events Tags, Evolutionary Events (Light Blue), Extinction Events (Red), Geologic Events (Yellow), Plastic Straw, Cartolina Paper. Markers, Colored Chalk

Resources

- (1) Carlson, D.H., Carlson, Plummer, C.C., and Hammersley, L., 2011. Physical Geology: Earth Revealed. McGraw-Hill. 645 p.
- (2) Desonie, D., 2015. CK-12 Earth Science High School . <http://www.ck12.org/earth-science/>
- (3) Junine, J.I., 2013. Earth Evolution of a Habitable World. Second Edition. Cambridge University Press. 304 p.
- (4) Kirkland, K. 2010. Earth Science: notable research and discoveries. Facts on File, Inc., 212 p.
- (5) Lutgens, F.K., Tarbuck, E.J. and Tassa, D., 2013. Essentials of Geology. 11th Edition. Pearson Prentice Hall, 554 p.
- (6) Tarbuck, E.J. and Lutgens, F.K., 2008. Earth – An Introduction to Physical Geology. 9th Edition Pearson Prentice Hall, 703 p.
- (7) Anne Briaies, Philippe Patriat, Paul Tapponnier, 1993. Updated Interpretation of Magnetic Anomalies and Seafloor Spreading Stages in the South China Sea : Implications for the Tertiary Tectonics of Southeast Asia. Journal of Geophysical Research : Solid Earth, American Geophysical Union, pp.VOL. 98, NO. B4, PAGES 6299-6328.
- (8) Aurelio, M.A., 2000. Shear Partitioning in the Philippines: Constraints from the Philippine Fault and global positioning system data. The Island Arc. VOL 9, PAGES 584 – 597

PRE- CLASS PREPARATION

1. Scout for an area or location that is ~ 50 m long (e.g. a hallway, gym, multipurpose hall, open area);
2. Assess for hazards specially if area chosen is outdoors (e.g. interaction with vehicles);
3. Cut cartolina (four different colors) into notebook size pieces
4. Using a permanent marker, write down on the cartolina the significant events in Earth's History , Use a separate color per event type (Event Tags)
5. Print out several copies of the blank geologic time scale which can be downloaded from: <http://serc.carleton.edu/files/introgeo/interactive/examples/bgeotime.pdf>

INTRODUCTION (5 MINS)

1. Introduce the following learning objectives :
 - a. Appreciate the immensity of geologic time and recognize that the Earth has a very long history;
 - b. Identify the timing and duration of the major events in Earth's History;
 - c. Recognize how short human history is in relation to the history of the Earth

MOTIVATION (10 MINS)

1. The teacher draws a 24 hour clock on the board. He or she then proceeds to ask the students "How old is the Earth?" When the correct age of the Earth has been established, the teacher then compares geologic time to a 24 hour clock. The teacher then marks some important events in Earth's History in the 24 hour clock:
 - a. First prokaryotes
 - b. First Eukryotes
 - c. First multicellular organisms
 - d. Extinction of the Dinosaurs
2. Inform or remind students that modern humans emerged during the last ~200,000 years. Ask the students to place the emergence of man in the 24 hour clock of Earth's History. We are relatively "new" to the Earth yet the our impact to the Earth System has been profound!

Teacher Tips:

- Preferably ~ 50 m long but can be shorter
- If area chosen is unpaved, the teacher can attach event tags to barbecue sticks which can be pegged into the ground
- Make several copies of event cards to be distributed to the number of intended groups

Teacher Tips:

- The age of the Earth should have been stated in the previous lesson (Origin of the Solar System - ~ 4.6 Billions of Years Old)
- Prokaryotes are organisms with a cell without a nucleus; Eukaryotes –cells with a nucleus.
- Emphasize for the first 2/3rd of Earth's History , the planet was inhabited by only single celled organisms.
- Humans appeared during the last few seconds of the last minute of the 24 hour clock.
- Emphasize how seemingly insignificant human history is in relation to Earth's History

INSTRUCTION/ DELIVERY/ PRACTICE (45 MINS)

Give a demonstration/lecture/simulation

Lecture proper (Outline)

This lesson was adapted from: http://www.teachersdomain.org/resource/tdc02.sci.life.div.lp_divdeeptime/

Activity

Divide class into groups of 5 -10 students. Distribute the blank geologic time scale to each student. Each group will create their own time scales. In the preselected area, use a measuring tape to lay-out a line measuring 46 meters. Use a plastic straw or draw a line using colored chalks (if the ground surface allows). Mark one end as "Today" and the other end as 4.6 billion years. Subdivide the line into 46 one meter sections each representing 100 million years. Mark each subdivision with a masking tape or with colored chalk. Ask the students to arrange the event cards along their respective time scales according to their date.

Optional : Ask the students to represent some of significant events by means of drawings (if the surface allows) using colored chalk.

Evolutionary events (Light Blue):

- a. First evidence of life (3,850 ma)
- b. Photosynthesizing bacteria (3,700 ma)
- c. Oldest fossils (3,500 ma)
- d. First Eukaryotes (2,700 ma)
- e. Ediacaran Fauna (600 ma)
- f. The Cambrian Explosion (530 ma)
- g. First land plants and fish (480 ma)
- h. Arthropods on land (420 ma)
- i. First insects (407 ma)
- j. First amphibians land vertebrates (375 ma)
- k. First dinosaurs (220 mya)
- l. Early mammals (220 mya)
- m. First birds (150 ma)
- n. First flowering plants (130 ma)

Teacher Tips:

- If the space is limited, cut the total length to 26 meters. Subdivide the 26 meters into half a meter sections (half a meter = 100 million years)
- Most of the dates for the significant events were taken from: <http://www.pbs.org/wgbh/evolution/change/deeptime/index.html>
- Point out the significance of the emergence of photosynthesis with regard to the evolution of the Earth's atmosphere (example of how components of the Earth System interact)
- The Ediacaran Fauna represents the first metazoans (organisms with more than one type of cell).
- The Cambrian Explosion is an evolutionary burst of animal origin. Most of the major phyla originated from the Cambrian Explosion.

- o. Early Primates 60 ma
- p. First hominids (5.2 ma)
- q. Modern humans (0.2 ma)

Extinctions (Red):

- a. End Ordovician – 25% of marine vertebrates families and 57% of genera became extinct (443 ma)
- b. Devonian – 50 -55% of marine invertebrate genera and 70-80 % of species go extinct (364 ma)
- c. Permian – greatest extinction event; 90% of all species became extinct (250 ma)
- d. End Cretaceous – extinction of the Dinosaurs; 60-80% of all species became extinct (65 ma)
- e. Late Pleistocene – nearly all large mammals and birds (>45 pounds) became extinct (.01 ma)

Geologic Events (Yellow):

- a. Formation of the great oceans (4,200 ma)
- b. Oxygen Levels reach 3% of the Atmosphere (1.9 ma)
- c. Protective Ozone in place (600 ma)
- d. Gondwana forms (500 ma)
- e. Oxygen nears present day concentration (400 ma)
- f. Formation of Pangaea supercontinent (280 ma)
- g. Pangaea supercontinent breaks up (200 ma)
- h. Continents near present-day positions (40 ma)
- i. Initiation of Seafloor Spreading of South China Sea (32 ma)
- j. Initiation of the Philippine Fault (4 ma)
- k. Global ice ages begin (2 Ma)

The teacher selects one of the time scales made by the students and leads the discussion of the History of the Earth. Ask the students to recall how the solar system formed at around 4.6 billion of years ago

Teacher Tips:

- There had been many (>>5) mass extinction events in Earth's history. Mass extinction is a rule rather than the exception. Mammals would not have become dominant if the dinosaurs did not become extinct!
- Speculated cause for mass extinction events include: meteor/bolide impact, large scale volcanism, and climate change. Some of these may have act in concert with each other.

Teacher Tips:

- Emphasize the interaction among the components of the Earth System in the evolution of the Atmosphere and Hydrosphere
- The biosphere "infected" the atmosphere with O₂ through photosynthesis
- Pangea is not the only supercontinent that existed in the past. Continents have broken apart and re-assembled several times in the past.
- Climate over the last 2 million years have oscillated between Ice Age (Glacial Periods) and Non Ice Age (Interglacial Periods). The Earth is currently in the tail end of an interglacial period.

Teacher Tips:

- Make sure that students are taking down notes during the discussion.
- Start from one end (4.6 Ga) and literally walk through the history of the Earth

The Precambrian or Cryptozoic Era (4.6 Ga – 540 Ma)

- a. Represents 80% of Earth's history
- b. Eon of "Hidden Life" – fossil record obscure. Ask the students why there is very little record of life during the Precambrian

Hadean Eon (4.56 -3.8 Ga)

- a. From "Haedes" Greek god of the underworld
- b. Chaotic time, lots of meteorite bombardment
- c. Atmosphere reducing (Methane, Ammonia, CO₂)
- d. Start of the hydrologic cycle and the formation of the world oceans
- e. Life emerged in this "hostile" environment

Archean Eon (3.8 – 2.5 Ga)

- a. Anaerobic (lack of oxygen)
- b. No Ozone
- c. Photosynthetic prokaryotes (blue green algae) emerged and started releasing oxygen to the atmosphere
- d. Life forms still limited to single celled organisms without a nucleus (prokaryotes) until 2.7 Ga when Eukaryotes emerged.

Proterozoic Eon (2.5 Ga to 540 Ma)

- a. Oxygen level reaches ~ 3% of the atmosphere
- b. Rise of multicellular organisms represented by the Vendian Fauna
- c. Formation of the protective Ozone Layer

Phanerozoic Eon (540 Ma to Present)

- a. Eon of "visible life"
- b. Diversification of life. Many life forms represented in the fossil record
- c. Life forms with preservable hard parts

Paleozoic Era (540 – 245)

- d. Age of "Ancient Life"
- e. Rapid diversification of life as represented by the Cambrian Fauna (Cambrian Explosion)
- f. Dominance of marine invertebrates

Teacher Tip:

Possible response include : 1) not much life during this period; 2) only simple life forms existed, may not have preservable hard parts.

Teacher Tips:

- Ask the students to recall how the Earth's primitive atmosphere and oceans formed
- There are many theories on how life on Earth began. Teacher can assign this as a topic of research.

Teacher Tip:

The Ozone layer protects life on the surface of the Earth from harmful UV rays. This may have allowed life to emerge from the oceans.

Teacher Tip:

Provide more details using the event cards.

- g. Plants colonize land by 480 ma
- h. Animals colonize land by 450 ma
- i. Oxygen level in the Atmosphere approaches present day concentration
- j. Massive Extinction at the end (End of Permian Extinction)

Mesozoic Era (245 – 65 Ma)

- a. Age of Reptiles
- b. Dominance of reptiles and dinosaurs
- c. Pangea starts to break-apart by 200 ma
- d. Early mammals (220 mya)
- e. First birds (150 ma)
- f. First flowering plants (130 ma)
- g. Mass Extinction at the end of the Cretaceous (65 ma)

Cenozoic Era (65 ma to present)

- a. Age of Mammals
- b. Radiation of modern birds
- c. Early Primates 60 ma
- d. Continents near present-day positions (40 ma)
- e. First hominids (5.2 ma)
- f. Modern humans (0.2 ma)
- g. Global ice ages begin (2 Ma)

At the end of the activity, ask the students, using their notes, to populate the blank geologic time scale with important events in Earth's History.

ENRICHMENT (25 MINS)

Ask the students to write a report (200 to 300 words) on one of the following topics:

1. Theories on the Origin of Life
2. Possible Causes of Mass Extinction Events
3. How mankind is driving the next mass extinction event

Teacher Tips:

- Provide more details using the event cards
- The term "Dinosaurs" is used for land reptiles that live from 230 to 65 ma. The term is not use for flying and marine reptiles that lived during the same period
- Ask the students if the rise of dominance of the mammals would have occurred if not for the mass extinction event at the end of the Mesozoic.
- Mass extinction events are important drivers in the evolution of life on Earth

EVALUATION				
	1 (NOT VISIBLE)	2 (NEEDS IMPROVEMENT)	3 (MEETS EXPECTATIONS)	4 (EXCEEDS EXPECTATIONS)
The student knows the age of the Earth				
The student shows familiarity with the timing and duration of the important biologic and geologic events in Earth's History.				
The student can enumerate some of the most important Mass Extinction Events				
The student can explain the significance of these Mass Extinction events in the evolution of life on Earth				
The student can give examples of how components of the Earth System have interacted through time.				

Lesson 18: Natural Hazards, Mitigation and Adaptation: Geologic Processes and Hazards

Content Standards

The learners demonstrate an understanding of the different hazards caused by geological processes (earthquakes, volcanic eruptions and landslides). The learners shall be able to conduct a survey to assess the possible geologic hazards that your community may experience.

Learning Competencies

The learners shall be able to describe the various hazards that may happen in the event of earthquakes, volcanic eruptions, and landslides **(S11/12ES-If-30)**; use hazard maps to identify areas prone to hazards brought about by earthquake, volcanic eruptions and landslides **(S11/12ES-If-31)**; and give practical ways of coping with geological hazards caused by earthquake, volcanic eruptions and landslides **(S11/12ES-If-32)**.

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Describe and explain the hazards associated with earthquakes;
2. Identify areas from the Philippine map where earthquakes are most likely to happen;
3. Identify and give examples of possible geologic hazards associated with earthquakes;
4. Demonstrate their understanding of the scope of the effects and damage of earthquakes by determining the possibility of such effects occurring in their area and vicinity and where it will most likely happen; and
5. Manifest awareness by participating in earthquake-related hazard prevention activities and drills.

LESSON OUTLINE

Introduction	Presentation of objectives and review of past lessons	15
Motivation	Structural map of the Philippines	15
Instruction	Group Activity	65
Enrichment	Campaign material	25

Materials

Projector, computer/laptop, manila paper, marker pens, metacards, videoclips of earthquakes associated hazards (all the different hazards are incorporated into one video), structural map of the Philippines; poster materials from Phivolcs on what to do before, during and after earthquakes.

INTRODUCTION (15 MINS)

1. Introduce the lesson of the day as well as the expected learning outcomes.
2. Review the learners on their past lessons on plate tectonics and earthquakes. Ask the following questions to know if they still remember or understood these basic concepts:
 - a. What are tectonic plates and the concept of plate tectonics?
 - b. What are the relationships of plate tectonics and faults with earthquakes
 - c. What are the P, S, and surface waves?
 - d. Explain the difference between: magnitude vs. intensity; Richter scale vs. Mercalli scale; and epicenter vs. focus.
3. Introduce the following terms:
 - a. Natural hazards
 - b. Risk
 - c. Vulnerability
 - d. Ground shaking / ground rupture
 - e. Tsunamis
 - f. Earthquake-induced landslides
 - g. Liquefaction and Subsidence

MOTIVATION (15 MINS)

1. Together with the learners, locate possible places where earthquakes are most likely to happen using the structural map of the Philippines.
2. Ask the learners to name a recent earthquake that they remember.
3. Locate that earthquake in the map.
4. If the earthquake they identified is one that they have also experienced, ask them to share to the class what they experienced, what they saw, and what damages they observed.
5. If the earthquake they identified is one that they did not experience, ask them of what they have heard regarding damages etc.
6. List their answers on the board or write their answers in a manila paper.

Teacher Tips:

Make sure that the learners understood the concepts on plate tectonics and faults, so they will have a clear understanding of the structural map. Make sure to point out the trenches, and if possible, make cross section drawings for visualization purposes.

It is important that the teacher knows of any recent earthquake occurrences and their respective locations.

INSTRUCTION / PRACTICE (65 MINS)

1. *Group Activity:* Identifying earthquake hazards (video clip review; 30 minutes)
 - a. Divide the learners into 5-6 groups depending on how many hazards are incorporated in the video.
 - b. Ask them to carefully view the video and identify as many hazards that they observed in the clip.
 - c. On a manila paper, have them write down their list of hazards with their description of each hazards that they identified. Remind them to include the corresponding effect of these hazards to the area, people and infrastructure.
2. *Group Activity:* Presentation or sharing of what they identified in the video (35 minutes; maybe conducted next meeting).
 - a. The teacher may ask for volunteers who will present or share first.
 - b. Each group will present one hazard. They should post their manila paper in front of the class.
 - c. Ask the class to comment on what the group has shared. The other students can add more or perhaps make corrections or disagree.
 - d. For additional observations, these must be written in metacards and taped along one part of the Manila paper.
3. Once all groups have presented, the teacher will have to synthesize the hazards presented in the video clip.
4. *Discussion:* Use the posters from Phivolcs on what to do before, during and after an earthquake.

ENRICHMENT

1. Retaining the same groupings, ask the learners to come up with a campaign material for the students of the school. The campaign material must:
 - a. contain information on the potential danger of earthquake hazards within the school;
 - b. be a brochure, poster, or a Powerpoint presentation;

Teacher Tips:

The video clip must be:

- short; with 5 minutes maximum runtime
- incorporating all natural hazards possible

The teacher may use pictures if a video clip is not available.

The video clip presentation and first group activity may take more or less than 30 minutes. As such, the reporting of their work may be set for next meeting.

The teacher must facilitate and validate the sharing within the learners' presentation, or add more insights when needed. The teacher may allot only 5 minutes per group.

1. Have the learners identify the grade level they aim to inform with the potential risks of earthquake and what they must do to minimize the damage. If possible, the groups must work on the same grade level.
2. Have their campaign materials posted or shown (for Powerpoint presentations) to a selected class.
3. The teacher must hold a discreet evaluation with the selected class to evaluate the campaign materials of the students.

Teacher Tip:

It would be good to have the students conduct their presentation to the same grade level they are with.

It would also be equally interesting to know how they will educate younger students.

EVALUATION

1. This will be based on two things:
 - a. Their group activity on the identification of the hazards and presenting this to the class
 - b. The campaign material that the group are able to come up with. They will be evaluated by the students that they will be presenting to.

Lesson 19: Natural Hazards, Mitigation and Adaptation: Geologic Processes and Hazards

Content Standard

The learners demonstrate an understanding of the different hazards caused by geological processes (earthquakes, volcanic eruptions and **landslides**). The learners shall be able to conduct a survey to assess the possible geologic hazards that your community may experience. (Note: Select this performance standard if your school is in an area near fault lines, volcanoes, and steep slopes.)

Learning Competencies

The learners shall be able to identify human activities that speed up or trigger landslides (**S11/12ES-If-33**) and suggest ways to help lessen the occurrence of landslides in your community (**S11/12ES-Ig-34**)

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Identify and understand how certain human activities can hasten the occurrence of landslides.
2. Find possible and practical solutions on how to lessen these identified human activities so as to lessen or prevent the occurrence of landslides.
3. Design an information campaign to inform locals how they contribute to the occurrence of landslides in their area.

LESSON OUTLINE

Introduction	What do you do for the day?	5
Motivation	Short Exchange on Field Activities	15
Instruction	Go around community and assess their area	40
Practice	Homework	
Materials		
Projector; computer; Data from previous field activity		
Hazards maps the class made for their community		

INTRODUCTION/REVIEW (5 MINS)

A 5 minute introduction to what you plan to do for the day.

Teacher Tip:

Make sure that the materials need, including the model used in the previous lesson has been repaired for this lesson.

MOTIVATION (15 MINS)

1. Have a short exchange of experience with the students of their field activities.
2. Determine from the class what they learned about landslides and their corresponding hazards.
3. Ask them, based from their field exposure, if they think we, in our own way, do contribute to the occurrence of landslides and in what way.

Teacher Tip:

Never forget to always write their answers on the board or use meta-cards for the students to write using keywords, what they experience etc.

INSTRUCTION / DELIVERY / EVALUATION (40 MINS)

1. Use the model that the class used during the first lessons on landslides.
2. Demonstrate each of the listed activities below how these can trigger or hasten the occurrence of landslides.
3. The following are the list of most common human activities that will trigger and hasten the occurrence of landslides.
 - a. Removal of vegetation
 - b. Interference with, or changes to the natural drainage
 - c. Leaking pipes such as water and sewer
 - d. Modification of slopes by construction of roads, railways, buildings, subdivisions
 - e. Overloading slopes
 - f. Mining and quarrying activities
 - g. Vibration from heavy traffic, blasting during road constructions of nearby mining activities
 - h. Excavation of rocks
4. Ask the students to write their own observations for each of human activities.
5. Ask them which of the following list of human activities are applicable to their communities.
6. Ask them if they are other human activities which they think can also hasten landslides.
7. If you think that it is valid (answer to question 5), then add it to the list.

Teacher Tip:

Make sure that the list of human activities is all represented in the model that you will in class. It is best that you have to do the demonstration first before doing it in class.

PRACTICE (HOMEWORK)

1. From the class activity, ask the students to list down any human activities in the list that they believe are applicable to their community.
2. Instruct them, in table form to list the human activities applicable to their community .
3. First column will be the human activity which they believe are contributing to the occurrence of landslides in their community.
4. Second column; ask them to write down how these can be prevented, or if these existing activities can still be prevented.

Teacher Tip:

It is better to draw the table form on the board so students will just copy.

ENRICHMENT (TO BE DONE AS AN ASSIGNMENT)

As a project: ask the students (you can group your students into groups of four) to come up with an information board or placard or poster containing the following information:

- a. What are landslides
- b. What may cause or trigger landslides
- c. How human activities can hasten the occurrence of landslides

Lesson 20: Natural Hazards, Mitigation and Adaptation: Hydrometeorological Phenomena and Hazards

Content Standards

The learners demonstrate an understanding of the different hazards caused by hydrometeorological phenomena (tropical cyclones, monsoons, floods and tornadoes *or ipo-ipo*).

The learners shall be able to conduct a survey to assess the possible geologic hazards that your community may experience (Note: select this performance standard of your school is in an area near fault lines, volcanoes and steep slopes); and conduct a survey or design a study to assess the possible hydrometeorological hazards that your community may experience. (Note: select this performance standard if your school is in an area that is frequently hit by tropical cyclones and is usually flooded.

Learning Competencies

The learners will be able to describe the various hazards that may happen in the wake tropical cyclones, monsoons, floods or *ipo-ipo* (**S11/12ES-Ig-35**); and use hazard maps identify areas prone to hazards brought about by tropical cyclones, monsoons, floods or *ipo-ipo*. (**S11/12ES-Ig-36**)

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Identify and classify the different types of hydrometeorological hazards.
2. Evaluate their community for potential hazards induced by extreme atmospheric and hydrologic conditions.

LESSON OUTLINE

Introduction	Communicating Learning Objectives	5
Motivation	Show pictures of hydrometeorologically induced hazards	10
Instruction	Hydrometeorological processes and hazards	30
Practice	Maps to know areas that will be affected by hydrometeorological hazard	15

Materials

Projector; computer; Maps from PAGASA showing the general typhoon tracks in the Philippines; Hazard maps from DENR and/or Project Noah Maps; and Tracing paper, pencils, erasers, markers

Resources

- (1) Tarbuck, Lutgens and Tasa. 2008. Earth: An Introduction to Physical Geology,, 9th edition.
- (2) Luvine, J. Earth: Evolution of a Habitable World, 2nd edition.
- (3) Kirkland, K. 2010. Frontiers of Science: Earth Sciences – Notable Research and Discoveries
- (4) Lutgens, Tarbuck and Tasa, Essentials of Geology, 11th edition.
- (5) Allaby, R. 2009. Earth Science: A scientific History of the Solid Earth
- (6) Botkin and Keller. 2011. Environmental Science: Earth as a living planet, 8th edition.
- (7) Carlson and Plummer. 2009. Physical Geology: earth revealed, 9th edition.
- (8) Hyndman and Hyndman. Natural Hazards and Disasters, 3rd edition.
- (9) Abbott, P.L. Natural Disasters, 8th Edition.
- (10) Bobrowsky, PT, editor. Encyclopedia of Natural Hazards.
- (11) PAGASA Website Annual Typhoon Track. <https://web.pagasa.dost.gov.ph/index.ph/tropical-cyclones/annual-tropical-cyclone-tracks>
- (12) Project Noah Website. <http://noah.dost.gov.ph>
- (13) DENR/MGB Website. <http://gdis.denr.gov.ph/mgbviewer/>

INTRODUCTION/REVIEW (5 MINS)

1. Communicate to the students what is expected of them during the discussions of the lesson.
 - a. I can identify and classify the different types of hydrometeorological phenomena / processes and hazards
 - b. I can evaluate communities for potential hazards induced by extreme atmospheric and hydrologic conditions
2. Ask the students about their understanding of the term "hydrometeorological". Write their responses on the board.

MOTIVATION (10 MINS)

1. Ask the students to identify the phenomena represented by the pictures.
2. Is there a link or connection among these phenomena?



The answers of students may vary. The most likely response would include weather and climate/ climate change. Explain/review the difference between climate and weather. The phenomena represented by the pictures are linked by meteorological, atmospheric, and hydrological processes.

Heavy rainfall can lead to floods. The lack of rainfall, on the other hand, results to drought and the higher incidence of wild fire.

The picture of a landslide may confuse some of the students. Recall that landslides are associated with sloping areas and that the primary driving mechanism is the pull of gravity. The trigger for a landslide however, can be an earthquake and/or **heavy rainfall**.

INSTRUCTIONAL DELIVERY (30 MINS)

PART 1 (5 MINS)

- a. Recall the student's definition of a hydrometeorological process.
- b. Piece together their responses to come up with definitions of the different Hydro-meteorological phenomena and hazards:

Hydrometeorological hazards are processes of atmospheric, hydrological or oceanographic nature that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Examples are tropical cyclones, monsoon rains (habagat and amihan), tornado, ipo-ipo and thunderstorms, floods, drought, wildfire and storm surges.

PART 2. THINK PAIR SHARE (15 MINS)

- a. 5 min to discuss with pair and 10 min to share their discussions to the class
- b. Divide the class into pairs. Make sure that there are at least 3 pairs assigned to each picture shown during the motivation part.
- c. The pairs will be assigned a question to answer:
 - i. Question for Pair 1: How do you think this phenomenon was formed? What could have triggered it to happen?
 - ii. Question for Pair 2: How will this phenomenon affect a community? What type of hazards is it associated?

Sources

Hydrometeorological phenomena

- Picture 1 – cyclone picture taken from space (<http://news.mit.edu/2015/small-thunderstorms-massive-cyclones-saturn-0615>)
- Picture 2 – thunderstorm (<http://aviationknowledge.wikidot.com/aviation:thunderstorms>)
- Picture 3. Tornado <http://www.kidzone.ws/science/tornado/facts.htm>
- Picture 4. Ipo-ipo <http://www.chaostrophic.com/cooked-aussie-ravers-get-a-whirlwind-experience-as-lads-run-inside-a-doofnado/>
- Picture 5. Monsoon rains <http://floodlist.com/asia/typhoon-rammasun-monsoon-rain-philippines>
- Picture 6 – floods <http://www.scmp.com/news/world/article/1869466/typhoon-koppu-deaths-shoot-nine-high-winds-and-floods-hit-northern>
- Picture 7 – wildfire <http://www.geog.ucsb.edu/~phil/research.htm>
- Picture 8– drought <http://www.ndtv.com/india-news/drought-in-bihar-jharkhand-no-silver-lining-in-sight-399850>
- Picture 9 – landslide <http://pmm.nasa.gov/applications/landslides>

The teacher can provide more pictures for students to identify and describe (for recall and familiarity)

- iii. Question for Pair 3: Think of an example where this phenomenon had seriously affected a community.
- d. The students must write their answers on a manila paper, post on the board, and briefly discuss to the class their output.

PRACTICE (15 MINS)

Map Reading

1. Typhoon tracks.

This must be done together with the students. Using the general yearly typhoon tracks of PAGASA:

- a. Locate your community (or any community that the class would like to check on) in the typhoon track map.
- b. From a given data set, go through the yearly typhoon tracks and determine if the location of your community is along the track of any typhoon. If yes, how often and what months did typhoons passed through your community?
- c. In which month/s is your locality most affected by typhoons.

2. Hazard determination

- a. Where is the community geographically located? Is it along or near the coast or near a river system? Is it along an elevated terrain and sloping topography? Is it within an urban area? With the geographic location identified, ask the students what type of hydrometeorological hazard would they expect? Ask them if they have actually experienced related disasters.
- b. Using the available hazard maps from MGB/DENR and Project Noah, determine if your community is susceptible to any hydrometeorological hazard. Identify which part of the community is affected (and by what type of hazard). What is the level of risk or severity (low, medium, high) in the event that a disaster would happen? Ask the students to make a list.

ENRICHMENT (AFTER CLASS ASSESSMENT / ASSIGNMENT)

If the class is able to identify a part of the community which is of significant risk to any hydrometeorological hazard, the teacher may ask the students to interview local officials (e.g. municipal officer or barangay officials) and find out the local government's disaster risk reduction plans,

Teacher Tip:

Validate, support and supplement the output of students.

Teacher Tips:

If students have access to a computer and internet at school, the teacher can guide students to use and navigate the PAGASA site. Otherwise, teacher can simply print-out annual typhoon tracks.

If your community is not within the path of any recorded typhoons, you can choose a place that is frequented by typhoons. Explain to the students that the impact of a typhoon is not limited to its track line. Surrounding communities covered by the diameter of the cyclone are also affected.

If near the coast, the community maybe susceptible to storm surge. If near river or in urban areas - flooding.

If near sloping areas - landslides

The teacher should know the difference between hazards, hazard susceptibility, risks and disasters.

As before, if the students do not have access to computers and internet, teacher can printout maps for the students.

There might be some difference between hazard maps produced by different government agencies or institutions. This might simply be because of difference in methodology. The difference should not be too great.

Lesson 21: Natural Hazards, Mitigation and Adaptation: Hydrometeorological Phenomena

Content Standards

The learners demonstrate an understanding of the different hazards caused by hydrometeorological phenomena (tropical cyclones, monsoons, floods and tornadoes or *ipo-ipo*). The learners conduct a survey to assess the possible geologic hazards that your community may experience (Note: select this performance standard of your school is in an area near faultlines, volcanoes and steep slopes); and conduct a survey or design a study to assess the possible hydrometeorological hazards that your community may experience. (Note: select this performance standard if your school is in an area that is frequently hit by tropical cyclones and is usually flooded).

Learning Competency

The learners will be able to give practical ways of coping with hydrometeorological hazards caused by tropical cyclones, monsoons, floods or *ipo-ipo*. **(S11/12ES-Ih-37)**

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Become familiar with the guidelines (government and private institutions) designed to help people prepare for and respond to the risks associated with flooding and other hazards.
2. Adapt and apply these guidelines to their school or to their community

LESSON OUTLINE

Introduction	Communicating Learning Objectives	5
Motivation	Videos on Hydrometeorological hazards	10
Instruction	Ways of coping with hazards	30
Practice	Simulation	10
Enrichment	After class activity	

Materials

Projector; computer; An evacuation plan of the barangay or municipality; Guidelines on how to prepare before, during and after floods; Basic materials that are needed during natural disasters and kept always in emergency kits.

Resources

- (1) Tarbuck, Lutgens and Tasa. 2008. Earth: An Introduction to Physical Geology,, 9th edition.
- (2) Luvine, J. Earth: Evolution of a Habitable World, 2nd edition.
- (3) Kirkland, K. 2010. Frontiers of Science: Earth Sciences – Notable Research and Discoveries
- (4) Lutgens, Tarbuck and Tasa, Essentials of Geology, 11th edition.
- (5) Allaby, R. 2009. Earth Science: A scientific History of the Solid Earth
- (6) Botkin and Keller. 2011. Environmental Science: Earth as a living planet, 8th edition.
- (7) Carlson and Plummer. 2009. Physical Geology: earth revealed, 9th edition.
- (8) Hyndman and Hyndman. Natural Hazards and Disasters, 3rd edition.
- (9) Bobrowsky, PT, editor. Encyclopedia of Natural Hazards.
- (10) What to do during and after flooding: http://president.gov.ph/gov_at_work/flood-safety-rules/
- (11) Guidelines on what to do during floods: <http://www.redcross.org/prepare/disaster/flood>
- (12) Preparing emergency kit: <http://www.redcross.org/get-help/prepare-for-emergencies/be-red-cross-ready/get-a-kit>
- (13) Safety tips on what to do before, during and after natural disasters: <https://www.youtube.com/watch?v=L0YutA1xHYs>

INTRODUCTION/REVIEW (5 MINS)

1. Clearly communicate learning competencies and outcomes and summarize and synthesize the previous lesson on the hydrometeorological hazards.

MOTIVATION (10 MINS)

1. Safety tips on what to do before, during and after natural disasters: <https://www.youtube.com/watch?v=LOYutA1xHYs>

INSTRUCTIONAL DELIVERY (30 MINS)

1. Hydrometeorological hazards, risks and disasters

a. What is hazard adaptation?

Hazard adaptation is knowing how to adjust or cope with an existing environmental condition in particular those pertaining to areas with potential hazards brought about by hydrometeorological phenomenon. To be able to do this, it is important to identify potential hazards and their potential impacts and effects to the community.

b. What is risk reduction?

Measures to reduce the frequency or severity of losses brought about by the effects of hazards. It is also a measure of reducing the exposure of people to the effects of hazards.

c. What is disaster mitigation?

These are measures or methods or strategies that eliminate or at least reduce the impacts and risks of hazards. There must be proactive measures done prior to a disaster to prevent loss of lives and properties. One very common mitigation measures against floods are river channel dikes.

2. Come up with / formulate guidelines for hydrometeorological hazard/s appropriate to a specific area (e.g. their school)
 - a. Ask the students to think about the **hazards** (potential to do harm to people, property, and/or the environment) associated with a typhoon and flooding. List their response on the board.
 - b. Provide the students a copy of the government and Red Cross (mitigating) guidelines. Go through each item on the list and try to identify which **risk** each item is trying to address.
 - c. As individual work or as part of a group, ask the students to put together their own guidelines which they think is appropriate for their school.
 - d. Inform and make the students aware that there are Disaster Reduction Management Councils

Teacher Tips:

Watch the video first and select the portions that are important to the lesson. The students can watch the entire video in some other time maybe after class and during their own free time.

Teacher Tips:

- Make the students realize that there are many disasters associated with flooding (e.g. damage to property, drowning, health related risks, electrocution etc.) and that these may vary depending on location (e.g. storm surge for coastal community, landslides for communities near slopes)
- It is important that students are able to understand the rationale behind each item on the guideline/s (e.g. *Do not go swimming or boating in flooded rivers*)
- Alternatively, instead of putting together individual emergency kits, the teacher can make one in front of the class. While assembling the kit, the teacher should explain the purpose of each item.

(e.g. (national) NDRMC, (provincial) PDRMC, (city) CDRMC, (municipal) MDRMC and (barangay) BDRMC) and these agencies have their own specific guidelines.

3. Preparing an emergency kit (you may use this website to come up with their own personal emergency kit: <http://www.disaster-survival-guide.com/emergency-kits/everyday-carry-kit/>)
 - a. With the materials that you asked the students to bring to school, organize their emergency kits.
 - b. Explain to the class the significance or purpose of each item in the emergency kit
 - c. Encourage each student to make sure that their respective homes should have an emergency kit.

Teacher Tips:

Teacher can group students according to barangays. Each barangay has a designated official responsible for disaster risk reduction.

Each barangay is required to identify an evacuation site (commonly a covered basketball court, barangay hall etc.)

PRACTICE (10 MINS)

- a. Simulating a hypothetical scenario where hydrometeorological hazards, risks and disasters are situationally inputted. What to do during emergencies? What safety guidelines and protocols to follow in such emergencies?
- b. Using the evacuation plan of the local community, plan with the class an evacuation for the entire class in case of disasters.
- c. This must also include plans on how to contact parents in case disasters do happen and they are still in school.

Outputs:

1. A route map showing how the class will evacuate, how to go about the area before finally reaching the set evacuation site.
2. Signage must be prepared and posted to designated area. This activity must be coordinated with the school.

ENRICHMENT (TO BE DONE AS AN ASSIGNMENT)

Ask each student to interview their respective barangay officials and find out the following:

1. Areas in their barangay susceptible to hydrometeorological hazards (e.g. flooding, storm surges and landslides)
2. Preparation and response of the Barangay to these hazards

Location of evacuations site/s

Location of nearest emergency health service (e.g. hospitals etc.)

Ask the student / group to submit a short report

Lesson 22: Natural Hazards, Mitigation and Adaptation: Marine and Coastal Processes and their Effects

Content Standards

The learners demonstrate an understanding of the different hazards caused by coastal processes (waves, tides, sea-level changes, crustal movement, and storm surges). Further, the learners shall be able to conduct a survey to assess the possible geologic hazards that your community may experience (Note: select this performance standard of your school is in an area near faultlines, volcanoes and steep slopes); conduct a survey or design a study to assess the possible hydrometeorological hazards that your community may experience.

Learning Competency

The learners will be able to describe how coastal processes result in coastal erosion, submersion and saltwater intrusion. **(S11/12ES-Ih-38)**

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

- (1) Recognize the coastal processes that influence the coastal landforms and associated hazards.
- (2) Illustrate and describe how the coastal processes determine the present coastal hazards whether coastal erosion, submersion or saltwater intrusion.

LESSON OUTLINE

Introduction	Presentation of the Objectives	5
Motivation	Activity on Maps	15
Instruction	Lecture	40
Enrichment	Assignment	

Materials

Projector, computer, map of the Philippines

Resources

- (1) Tarbuck, Lutgens and Tasa. 2008. Earth: An Introduction to Physical Geology,, 9th edition.
- (2) Luvine, J. Earth: Evolution of a Habitable World, 2nd edition.
- (3) Kirkland, K. 2010. Frontiers of Science: Earth Sciences – Notable Research and Discoveries
- (4) Lutgens, Tarbuck and Tasa, Essentials of Geology, 11th edition.
- (5) Allaby, R. 2009. Earth Science: A scientific History of the Solid Earth
- (6) Botkin and Keller. 2011. Environmental Science: Earth as a living planet, 8th edition.
- (7) Carlson and Plummer. 2009. Physical Geology: earth revealed, 9th edition.
- (8) Hyndman and Hyndman. Natural Hazards and Disasters, 3rd edition.
- (9) Abbott, P.L. Natural Disasters, 8th Edition.
- (10) Bobrowsky, PT, editor. Encyclopedia of Natural Hazards.
- (11) PAGASA Website Annual Typhoon Track. <https://web.pagasa.dost.gov.ph/index.php/tropical-cyclones/annual-tropical-cyclone-tracks>
- (12) Project Noah Website. <http://noah.dost.gov.ph>
- (13) DENR/MGB Website. <http://gdis.denr.gov.ph/mgbviewer/>

INTRODUCTION/REVIEW (5 MINS)

1. Communicate the learning outcome and the general outline of the lesson.
2. Introduction of a few new terms

Ask the students what they know about the following terms:

Coastal erosion	longshore drift	coastal deposition
Coasts	sea level rise	beach profile
Beach	submergence	swash
backwash		

3. As much as possible, let them explain or define the terms in their own words. Write the key words of their responses on the board.

Teacher Tip:

Make sure that you have given your students advance reading assignments on marine and coastal processes prior to the lesson.

MOTIVATION (15 MINS)



Teacher Tip:

When doing activity you can do the either of the following:

- a. Using a DLP, project the image into a viewing sheet or wall.
- b. Print out the maps and pin them to a wall or board so the students can go there and do the activity and at the same time discuss with other students.

Teacher Tip:

Give time for the students to observe the maps. Divide them into groups (usually 5 in a team to allow each to share their ideas) and give them time to talk and discuss on what they have observe. Ask a representative of each group to share the ideas of the team.

Activity 1. Observation of coastal lines.

- a. Ask the students to carefully study the two maps paying particular attention to the outlines of the continents (for the world map) and for the Philippines, the outlines of the islands. Say that these outlines represent the coastal areas.
- b. Ask them to describe the coastlines. You may get different answers: irregular, smooth outline, straight. You may ask them if they have an idea of why coastlines exhibit such forms. What are the

possible answers a teacher may expect to get? (I really don't know what possible answers the teacher can get from their students. What is important is the teacher knows how to filter out the correct or almost correct answers to the incorrect ones or what are expected.

- c. Give the list of countries with the longest coastlines (<http://geography.about.com/od/lists/a/longest-coastlines.htm>). Compare the size of the Philippines in terms of its area (does this refer to the length of the coastlines, areal extent etc?) relative to the rest of the countries in the list. Show to the students that even if the Philippines (teacher pointing to the Philippines) is small in area compared to the rest of the countries, it ranked 4th in terms of the length of its coastline.
- d. Ask this question to the students. Why is it that despite its small size, the Philippines ranked 4th in the longest coastline in the world.
- e. Get the answers of the question in step c from the students and write them on the board. After getting their answers, scan through their answers and check which is closest to the correct answer. At the point explain to them that despite its size, the Philippines ranked fourth in the list of the longest coastline in the world because we are a country composed of a lot of islands with irregular coastlines.

Activity 2. Coastal areas exposure to hazards. Show pictures of the effects of coastal erosion.



- a. Show the effects of coastal erosion leading to the destruction of houses and other infrastructures along the coasts and the steepening of the coastal area.
- b. Show the effects of submergence due to either the rising sea level or the lowering of coastal lands. Picture 5 shows how easily seawater can overtop sea dikes especially during stormy weather - a problem made worse by rising sea level and/or the subsidence of land.

Teacher Tip:

You can download or photocopy more pictures from the internet or books, respectively, of coastal hazards or pictures showing destructions along coastal areas.

Resources:

- Location: along a coastal area in Cebu, Philippines. <http://footage.framepool.com/shotimg/qf/632326044-cebu-hurricane-erosion-cliff-coastal-rock.jpg>
- Boracay, Philippines. <http://boracaysun.com/wp-content/uploads/2014/06/Alarming-coastal-erosion-along-Boracays-White-Beach-Photo-by-Cha-Santos-1024x768.jpg>
- Along Roxas Boulevard. http://blogs.worldbank.org/eastasiapacific/files/eastasiapacific/bloh-ph-climate-change_0.jpg

INSTRUCTION / DELIVERY / EVALUATION (40 MINS)

After the short introduction to coasts and coastal hazards, the teacher will now start to discuss the different coastal processes and their corresponding hazards.

The following are study notes that the teacher can refer to when developing his or her lecture materials.

The dominant coastal processes:

1. Coastal Erosion

Coastal Erosion is the wearing away of the land by the sea and is done by destructive waves.

Five common processes that cause coastal erosion:

- a. **Corrasion** is when waves pick up beach materials and hurl them at the base of a cliff
- b. **Abrasion** happens when breaking waves containing sediment fragments erode the shoreline, particularly headland. It is also referred to as the sand paper effect.
- c. **Hydraulic action.** The effect of waves as they hit cliff faces, the air is compressed into cracks and is released as waves rushes back seaward. The compressing and releasing of air as waves presses cliff faces and rushes back to sea will cause cliff material to break away.
- d. **Attrition** is the process when waves bump rocks and pebbles against each other leading to the eventual breaking of the materials.
- e. **Corrosion/solution** involves dissolution by weak acids such as when the carbon dioxide in the atmosphere is dissolved into water turning it into a weak carbonic acid. Several rocks (e.g., Limestone) are vulnerable to this acidic water and will dissolve into it. The rate of dissolution is affected by the concentration of carbonates & other minerals in the water. As it increases, dissolution becomes slower.

2. Sediment movement along coasts

As wave crashes on the shore, the water pushes sediment up the beach and then pulls it back down the beach as the water slides back down. If the waves do not come in parallel to the beach longshore transport (littoral drift) of sand occurs. When waves approach the beach at an angle, the part of the wave that reaches shallow water earliest slows down the most, allowing the part of the wave that is farther offshore to catch up. In this way the wave is refracted (bent) so that it crashes on the shore more nearly parallel to the shore. You will never see a wave wash up on a beach at a very high angle from the line of the beach except perhaps at an inlet or where the shore makes a sudden right angle bend.

Teacher Tip:

These teaching guides come with a powerpoint presentation on coastal hazards which the teacher can use as is or modify. If projector and computer are not available, the teacher can print out the photographs and develop his or her own lecture material.

If the school is near the coast, a short field trip to the coast to observe this processes is ideal. Dovetail this activity with other subjects or lessons (e.g. S11_12ES-li-39)

Note:

Longshore drift occurs when waves approach the beach at an angle. The swash (waves moving up the beach) carries materials up and along the beach. Then the materials were carried back towards the sea as part of the backwash.

3. Coastal deposition

When waves lose their capacity to carry or transport sediments because of a reduction in energy, they can and will "drop" or **deposit** its sediment load. Waves that do not have the capacity to transport sediments and which results to sediment deposition and accumulation are called constructive waves. Deposition happens when the swash (or the waves that rushes inland) is stronger than the backwash (waves rushing back to sea). Deposition can occur as waves enter areas of shallow water, sheltered areas like coves or bay, little or no wind, and there is a sufficient supply of sediments. Emphasize that the waves lose kinetic energy to transport the sediment load.

ENRICHMENT (TO BE DONE AS AN ASSIGNMENT)

Ask students to submit a poster showing the different hazards along the coastal areas.

Teacher tip

Teacher can also use this to reinforce the idea of interaction among the components of the Earth System.

Lesson 23: Natural Hazards, Mitigation and Adaptation: Marine and Coastal Processes and their Effects

Content Standard

The learners demonstrate an understanding of the different hazards caused by coastal processes (waves, tides, sea-level changes, crustal movement, and storm surges). The learners conduct a survey to assess the possible geologic hazards that your community may experience (Note: select this performance standard of your school is in an area near faultlines, volcanoes and steep slopes); and conduct a survey or design a study to assess the possible hydrometeorological hazards that your community may experience. (Note: select this performance standard if your school is in an area that is frequently hit by tropical cyclones and is usually flooded).

Learning Competency

The learners will be able to identify areas in your community prone to coastal erosion, submersion and saltwater intrusion. **(S11/12ES-li-39)**

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Identify and appraise their chosen area within the community for possible coastal hazards.
2. Design a field activity of a chosen coastal area to assess or monitor the present condition of the area.

LESSON OUTLINE

Introduction	Discuss learning objectives	10
Activity 1	Assessing the present condition of the beach	175
Activity 2	Determine potential hazards in the area	175

Materials

Clear map of your area / map of a selected area (this must be of smaller in scale); Hazard map of the local community. You can acquire this from the municipality or barangay.; Field notebook and pens/pencils; Plastic containers or plastic bags (small size) that will be used later for the sediments that the students will collect; and Measuring tape

Resources

- (1) Manual for Coastal Hazard Mitigation by the New Jersey Sea Grant college Program: http://www.state.nj.us/dep/cmp/coastal_hazard_manual.pdf
- (2) Coastal Hazards. http://dels.nas.edu/resources/static-assets/osb/miscellaneous/coastal_hazards.pdf
- (3) Coastal erosion and mitigation method. [http://nopr.niscair.res.in/bitstream/123456789/10799/1/IJMS%2039\(4\)%20521-530.pdf](http://nopr.niscair.res.in/bitstream/123456789/10799/1/IJMS%2039(4)%20521-530.pdf)
- (4) Coastal management part 1: <https://www.youtube.com/watch?v=CncST-S9uUI>
- (5) Coastal erosion mitigation: <http://revisionworld.com/gcse-revision/geography/coastal-landscapes/coastal-management>
- (6) Holland, barriers to the sea: <https://www.youtube.com/watch?v=aUqrBV4SiqQ>
- (7) Rising sea swallowing north American island: <https://www.youtube.com/watch?v=l0bKxgyEvTc>
- (8) Florida rising seas: <https://www.youtube.com/watch?v=-JbzyPWJk64>

INTRODUCTION/REVIEW (10MINS)

1. Briefly communicate the learning objectives.
2. Review the previous lessons on coastal processes and coastal hazards.

INSTRUCTION / DELIVERY / EVALUATION (350 MINS)

Activity 1: Assessing the present condition of the beach

1. Determining the origin and size of sediments of the beach.
 - a. Use the diagram below to explain where sediments found along the beach came from.
 - i. Lithics / or rock fragments = from the land brought to the coastal area by rivers.
 - ii. Biogenic sediments (corals, shells, from organic remains) = from the marine organism remains, coral reefs.
 - b. Collect sediment samples
 - c. Since this is just a simple activity, the students are not required to bring the samples back to the classroom unless they wanted to keep them. What is important here is that they will look closely at the sediments and determine what type of sediments are there.
 - d. A biogenic dominant sediments indicate a reefal origin of the sediments.
 - e. A lithic dominant sediment along the beach would indicate that most of the sediment source may come from the river, if there is a nearby river, if not, from the rocks surrounding the beach.
 - f. Set up a sampling line, perpendicular to the coastline. The sampling line should start from the present edge of the water at the beach face. Ask the student to indicate the relative location of the sample from the edge of the water) towards inland or the start of the vegetation.
 - g. Interval (specified depth and amount of sample to be collected. Observe and note carefully the kind of sediments (component +size) found within the sampling area. Also carefully determine the dominant grain size of the sediments by using the grain size comparator.
 - h. Importance of grain size:
 - i. Large grain size with the minimal to no finer grains would indicate a high energy coastal area. May indicate dominance of erosion process
 - ii. Finer grains – less energy
2. Determining the present profile of the beach using the Emery Method.
 - a. Measure the present beach profile using the Emery board method.
 - b. The emery method step by step procedure can be viewed here: http://www.beg.utexas.edu/coastal/thscmp/bch_prof_meas.php

Teacher Tips:

Determine the length of the beach area that will be covered for the activity.

Also locate in the map the activity area.

Divide the students into four groups:

Two groups will work on activity 1.

Two groups will work on activity 2.

Teacher will decide the distance between the two groups for each activity. Probably it would be a good idea to give some pointers for teachers in selecting where along the beach would be best to assign the students.

Teacher tip:

Although this is just a simple exercise, you have to make sure that the students will do the activity properly. You can make one grain size comparator as an activity when your students will take up sedimentary rocks.

ACTIVITY 2. DETERMINE POTENTIAL HAZARDS IN THE AREA.

Using the topographic and hazard maps of the DENR, discuss with the students the potential hazards in the area.

1. Students must survey the area. Observe carefully.
2. Using their field notebooks, they should record what they observe. Indicating if the feature they have observed is more of a product of erosional or depositional process.
3. Ask them to indicate in their maps where these potential hazards are found.
4. Discuss results with the students. Give some points for discussion to help teachers.
5. Come up with a final hazard map of the area with the inputs of the students.

Teacher Tip:

This is the method being used by the DENR to monitor beach profiles. You may request a DENR personnel to teach the method to the class.

PRACTICE

1. Ask the students to come up with a documentation report of what they have done (for the two activities).

ENRICHMENT (TO BE DONE AS AN ASSIGNMENT)

1. Ask the students to come up with a field design of the activity that they have done if they will be asked to monitor the condition of the area for two years.

EVALUATION				
	NOT VISIBLE	NEEDS IMPROVEMENT	MEETS EXPECTATIONS	EXCEEDS EXPECTATIONS
Rate the documentation report that they will submit.	No report submitted	If they are able to document about 50 percent of their activity	If they are able to completely document all their activities including enumerating the different hazards.	Not only are they able to completely document all their activities and the different hazards, they will also give a few insights regarding what must be done regarding the hazards.

Lesson 24: Natural Hazards, Mitigation and Adaptation: Marine and Coastal Processes and their Effects

Content Standards

The learners demonstrate an understanding of the different hazards caused by coastal processes (waves, tides, sea-level changes, crustal movement, and storm surges). The learners shall be able to conduct a survey to assess the possible geologic hazards that your community may experience (Note: select this performance standard of your school is in an area near faultlines, volcanoes and steep slopes); conduct a survey or design a study to assess the possible hydrometeorological hazards that your community may experience. (Note: select this performance standard if your school is in an area that is frequently hit by tropical cyclones and is usually flooded).

Learning Competencies

The learners will be able to give practical ways of coping with coastal erosion, submersion, and saltwater intrusion (**S11/12ES-li-40**); cite ways to prevent or mitigate the impact of land development, waste disposal, and construction of structures on coastal processes (**S11/12ES-li-41**)

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Explain the different ways to cope with coastal hazards, particularly on coastal erosion, submersion and saltwater intrusion.
2. Evaluate the appropriateness and effectivity of the different mitigation measures to minimize or prevent various coastal hazards.

LESSON OUTLINE

Introduction	Communicating Learning Objectives	5
Motivation	Video viewing	10
Instruction	Discussion with students	30
Practice	Activity on Coastal Hazard Mitigation	15

Materials

Projector; computer

Resources

- (1) Manual for Coastal Hazard Mitigation by the New Jersey Sea Grant college Program: http://www.state.nj.us/dep/cmp/coastal_hazard_manual.pdf
- (2) Coastal Hazards. http://dels.nas.edu/resources/static-assets/osb/miscellaneous/coastal_hazards.pdf
- (3) Coastal erosion and mitigation method. [http://nopr.niscair.res.in/bitstream/123456789/10799/1/IJMS%2039\(4\)%20521-530.pdf](http://nopr.niscair.res.in/bitstream/123456789/10799/1/IJMS%2039(4)%20521-530.pdf)
- (4) Coastal management part 1: <https://www.youtube.com/watch?v=CncST-S9uUI>
- (5) Coastal erosion mitigation: <http://revisionworld.com/gcse-revision/geography/coastal-landscapes/coastal-management>
- (6) Holland, barriers to the sea: <https://www.youtube.com/watch?v=aUqrBV4SiQ>
- (7) Rising sea swallowing north American island: <https://www.youtube.com/watch?v=l0bKxgyEvTc>
- (8) Florida rising seas: <https://www.youtube.com/watch?v=-JbzypWJk64>

INTRODUCTION/REVIEW (5 MINS)

1. Presentation of the learning objectives.

Review the past lessons and activities. This time, emphasize the importance of knowing the first two lessons because the outcome of those will be the basis for mitigation which will be the topic for this lesson.

MOTIVATION (10 MINS)

1. From the references given, choose the best video (or if you have other videos on coastal mitigation documentary) and show this to class.
2. Ask the students to pay particular attention to the methods applied to prevent or to lessen the effects of coastal hazards.
3. Ask them to note the comparison of the the area that they are watching in the documentary with their field area, and whether the mitigation that they have seen in the documentary will work in the field area that they had just worked on.

INSTRUCTION / DELIVERY / EVALUATION (30 MINS)

1. A powerpoint lecture presentation has been prepared for this lesson.
2. Check out: <http://bit.ly/coastalprocesses>

PRACTICE (15 MINS)

Assess their field area and determine what mitigation measures, based on what they have seen in the video, are applicable to mitigate the hazard that they have identified in their field area.

1. Use the same grouping during their field activity.
2. Give the group 5-10 min to discuss.
 - a. What they consider to be the best mitigation to prevent or lessen the effect of the hazard present in their field area.
 - b. Are there man-made structures that have modified coastal processes? If yes, in what way?
3. Each group nominates a member to share with the class the results of their group discussion (basically responses to the guide questions that they will use for their group discussion). Results/output are all written on the board.

Teacher Tip:

You have to guide your students during the entire process.

The report is just a simple presentation of what the objective of their activity, what they did to accomplish or reach their objective and then what came out or the output of their activity.

4. The class will then try to agree on the best possible solution depending on the features of the beach section studied by the group (this applies to classes which may have several groups which means the class will be covering a larger area)

ENRICHMENT (TO BE DONE AS AN ASSIGNMENT)

1. It must be emphasized to the class that their output must be shared to the community that will be affected by the coastal hazards.
 - a. Let the students decide to who they would like to share their information: To the students of the barangay or the local community or the local officials
 - b. Whichever they decide on, require your students to submit a plan or design on how they will do the activity of presenting the report. (They may or may not go to the area and share their outputs)

Lesson 25: Introduction to Life Science

Content Standards

The learners demonstrate an understanding of the historical development of the concept of life; the origin of the first life forms; and the unifying themes in the study of life. The learners shall be able to appreciate and value life by taking good care of all beings, humans, plants and animals.

Learning Competencies

The learners will be able to explain the evolving concept of life based on emerging pieces of evidence (**S11/12LT-IIa-1**); describe classic experiments that model conditions which may have enabled the first life forms to evolve; (**S11/12LT-IIa-2**); and describe how unifying themes (e.g. structure and function, evolution and ecosystems) in the study of life show connections among living things and how they interact with each other and with their environment; (**S11/12LT-IIa-3**)

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Discuss the historical development of the concept of life including theories, experiments and evidences;
2. Describe the conditions on early Earth that made the origin of life possible and the first life forms; and
3. Discuss the unifying themes of life and how they are interconnected

LESSON OUTLINE

Introduction Communicating Learning Objectives

Motivation Visual Images and Stereotyping

Instruction Poster making and Gallery Walk

Practice Cafe Conversations

Enrichment Close Reading Protocol

Evaluation After Class (Self and Peer Assessment)

Materials

Writing and coloring materials, sheets of paper, photos of organisms, white cartolina/manila paper

Resources

- (1) Reece JB, Urry LA, Cain ML, Wasserman SA, Minorsky PV, Jackson RB. Campbell Biology. 10th edition. San Francisco, California, USA: Pearson Education Inc.; 2014. 49-59;471-476;519-530;612-680pp.
- (2) The Origin and Early History of Life. <http://www.mhhe.com/biosci/genbio/raven6b/graphics/raven06b/other/ch04.pdf>. 7 August 2015.
- (3) Gallery Walk. <http://serc.carleton.edu/introgeo/gallerywalk/index.html>. 7 August 2015.
- (4) Poster Rubrics. <http://www.rubrics4teachers.com/poster.php>. 7 August 2015.

INTRODUCTION (15 MINS)

Communicate learning objectives

1. Introduce the following learning objectives using any of the suggested protocols (Verbatim, Own words, Read-aloud)
 - a. I can discuss the historical development of the concept of life including theories, experiments and evidences.
 - b. I can describe the conditions on early Earth that made the origin of life possible and the first life forms.
 - c. I can discuss the unifying themes of life and how they are interconnected.

Review

1. Say, "When you are already thinking like a biologist, many interesting questions probably occur to you when you are outdoors surrounded by the natural world. It is undeniable that more than anything else, biology is a quest of ongoing inquiry about the nature of life and even the origin of life."
2. The most fundamental question, we may ask: What is LIFE?
 - a. At this point students may respond objectively or subjectively but do consider their responses regardless of its objectivity and subjectivity. You will be amused how each one consider, view, understand and value life.
 - i. **Sample responses:**
 - Life is like a box of chocolates, you will never know what you will get.
 - Life is a rollercoaster ride.
 - Life is that which delineates living from non-living form.
 - Life is mysterious.
 - b. Ask a few students to say out loud their definition of LIFE then, to further allow them to delve into LIFE, ask students to write their definition, view and understanding of life in a piece of paper (they are to submit their papers afterwards).
 - c. Say, "Even a small child realizes that a cat or a plant is alive while rocks and cars are not. However, a phenomena called LIFE transcends a succinct one sentence/ phrase definition. It is because we recognized life by what living things do, apparently by the characteristics/ properties associated with life. (At this point the characteristics of life will be tackled one by one to motivate the students).

Teacher Tip:

Refer to Campbell Biology.10th edition. San Francisco, California, USA: Pearson Education Inc.; 2014. Chapter 1: Inquiring about Life

MOTIVATION (20 MINS)

Analyzing Visual Images and Stereotyping

1. Break students into groups (6 members each) to further look into the characteristics/properties associated with life.
2. Present to students photos of the following: (Show hard copies of the photos or flash them in the screen using a LCD/ projector)
 - a. A close-up picture of a sunflower showing the parts of the flower with the capitulum (head) showing the corolla disk (disk florets) and corolla rays of the flower (illustrating a highly ordered structure); could be pictures of flowers focusing on the structure and parts;
 - b. A pygmy seahorse camouflaging itself with its environment
 - c. A jackrabbit's ears opening wide, vividly showing its blood vessels
 - d. A butterfly obtaining fuel in the form of nectar from flowers.
 - e. A sprouting seed (e.g. an oak seedling)
 - f. A damselfly landing on a venus flytrap, with the flytrap rapidly closing its trap
 - g. A mother giraffe with its young calf standing beside her
 - h. A garden showing lush vegetation and diverse animals
3. Ask students to examine each photograph, think and write down in a sheet of paper their immediate observation of what characteristic of life is illustrated/ being portrayed in each photo.
 - a. Answers: The characteristics/ properties of life are the following:
 - i. High degree of organization (a)
 - ii. Evolutionary adaptation/ evolution and adaptation (b)
 - iii. Regulation and Homeostasis (c)
 - iv. Energy Processing/ Acquisition and use of energy (d)
 - v. Growth and Development (e)
 - vi. Response to the environment/ Ability to respond to stimuli (f)
 - vii. Reproduction (f)
 - viii. Diversity and Unity (h)
4. Expound more on the characteristics/ properties of life by citing examples. (This activity will broaden their view about life and will cause them to appreciate life)
5. Say, "Now we know what is life based on its characteristics/ properties, it is time to address questions, such as how did life started? What are some theories and evidences pertaining to life?"

Teacher Tips:

- Show students photos of organisms showing the characteristics/ properties of life. There are recommended photos to show however, it may be substituted by other photos available with the same attributes as not to forfeit the goal of the activity;
- Similar photos having same attributes can be shown simultaneously under one characteristic of life to facilitate stereotyping;
- Refer to Campbell Biology.10th edition. San Francisco, California, USA: Pearson Education Inc.; 2014. Chapter 1: Inquiring about Life
- Leave this question in mind to the students as you proceed to the next activity.

INSTRUCTION/DELIVERY (50 MINS)

Poster making/Preparation for Gallery Walk

1. Ask students to work in groups (4 members) – a class of 40 students will have 10 groups
2. Bring to class reading materials (books, journals etc.) and printed handouts. Provide students with handouts regarding historical development of the concept of life including theories and evidences.
3. Provide each group with one piece of white cartolina/ manila paper, writing and coloring materials (this can be pre-assigned to students before coming to class).
4. Each group will be tasked to make a poster pertaining to the historical development of the concept of life including theories and evidences. Students will choose the topic based on the provided list (no duplication). Guide the students in preparing the posters.
5. The topics are the following:
 - a. Theory of special creation
 - b. Cosmozoic theory
 - c. Theory of spontaneous generation or 'Abiogenesis'
 - d. Biogenesis Theory
 - e. Oparin's Theory
 - f. Coacervation Theory
 - g. J.B.S Haldane's Hypothesis
 - h. Urey-Miller hypothesis
 - i. Fossils (evidence of past life, significance and important fossils)
 - j. Geologic time scale (emergence of life forms)
6. The students should prepare the poster (to be used for gallery walk) based on the topic chosen or assigned to them. Ask the students to read through the resource materials provided as guide in making their own synthesis. The poster should be attractive and should contain important information. They are to synthesize the following details based on their understanding and will have to say it on their own words. The poster should have the following details:
 - a. Topic/ Title (e.g. Biogenesis Theory)
 - b. Proponents (e.g. Francisco Redi)
 - c. Leading questions (based on the topic, pose very important question/s; it should be appealing to audience such that they would be encouraged to read through); (e.g. When did the first life forms emerged? Does life come from life or non life? Explain how Francisco Redi proved the 'Biogenesis' theory.

Teacher Tips:

- The teacher beforehand can ask students (per group of 4 members) to bring one piece of white cartolina/ manila paper, writing and coloring materials when they come to class; They may bring reading materials pertaining to historical development of the concept of life including theories and evidences and first life forms;
- Before coming to class do your personal review on historical development of the concept of life including theories and evidences and first life forms; you may also bring resource and reading materials or handouts for the activity
- Explain the Rationale of the activity
- Distribute the reading materials and handouts; ask students to synthesize information based on it

Note: Ask students to prepare leading questions based around a topic's central concept, issue, or debate. The wording of the question depends on the desired learning skill or level of abstraction;

- d. Content/ details (answers to questions and facts provided)
 - e. References
7. Accomplished posters/ exhibits will be posted within the classroom (distribute it to the corners of the room) and students will be asked to move around the room for viewing of 'exhibits' (gallery walk). A rubrics will be presented and used to rate the posters made by groups.

Gallery Walk

1. Use gallery walk to give key information about the historical development of the concept of life including theories and evidences. The purpose of the gallery walk is to introduce students to new materials; teams will be taking informal notes as they walk around the room viewing the exhibits.
2. While doing the gallery walk all groups will read through the posters/ exhibit (comprehend facts and information delivered) and rate posters according to the rubrics presented.
3. Each team will write down other possible questions related to the topics that can possibly be included; or make comments and suggestions.
4. Informal notes taken relating to the topic will be used to fuel further discussions.
5. Discuss with students what they have learned.

Notes:

1. Gallery Walk gets students out of their chairs and actively involves them in synthesizing important concepts, in consensus building, in writing, and in public speaking. In Gallery Walk teams rotate around the classroom, composing answers to questions as well as reflecting upon the answers given by other groups. Questions are posted on posters located in different parts of the classroom along with answers based on readings of resource materials. Each chart or "station" has its own question that relates to an important class concept. The technique closes with an oral presentation or "report out" in which each group synthesizes comments to a particular question.
2. Students can take a gallery walk on their own or with a partner. They can travel in small groups, and simply announce when groups should move to the next piece in the exhibit. One direction that should be emphasized is that students are supposed to disperse themselves around the room. When too many students cluster around one poster, it not only makes it difficult for students to view the texts, but it also increases the likelihood of off-task behavior.
3. Gallery Walk is good in addressing a variety of cognitive skills involving analysis, evaluation, and synthesis, and has the additional advantage of promoting cooperation, listening skills, and team building.

Level questions based on:

- *Knowledge*-recall facts (Key Words: what, when, where, define, spell, list, match, name);
- *Comprehension*- understanding and stating key concepts and main ideas (Key Words: summarize, rephrase, explain, interpret, compare, contrast, outline, translate);
- *Application*- applying knowledge in new ways and in novel situations (Key Words: apply, solve, model, make use of, organize, experiment with, use);
- *Analysis*-breaking down information into key concepts, finding evidence (Key Words: analyze, find evidence for, examine, inference, assumption, categorize, conclusion, classify, compare, contrast, discover, dissect, inspect, simplify, relationships);
- *Synthesis*-combining elements in a novel way, proposing alternate solutions (Key Words: combine, create, design, develop, build, compile, compose, construct, formulate, imagine, invent, make up, originate, plan, predict, propose, change, improve, adapt, improve, change);
- *Evaluation*-making judgments based on accepted standards (Key Words: criticize, defend, dispute, evaluate, judge, justify, recommend, rule on, agree, appraise, assess)

Grading Rubric for Poster

	5	4	3	2	1
Content	Content is concise and accurate such that all required information is presented in a logical order.	Content is accurate but some required information is missing and/or not presented in a logical order, but is still generally easy to follow.	Content is accurate but some required information is missing and/or not presented in a logical order, making it difficult to follow.	Content is questionable. Information is not presented in a logical order, making it difficult to follow.	Content is inaccurate. Information is not presented in a logical order, making it difficult to follow.
Presentation	Presentation flows well and logically. Presentation reflects extensive use of tools in a creative way.	Presentation flows well. Tools are used correctly Overall presentation is interesting.	Presentation flows well. Some tools are used to show acceptable understanding.	Presentation is unorganized. Tools are not used in a relevant manner.	Presentation has no flow. Insufficient information
Pictures, Clip Art Background	Images are appropriate. Layout is pleasing to the eye.	Images are appropriate. Layout is cluttered.	Most images are appropriate	Images are inappropriate or layout is messy.	No images
Mechanics	No spelling errors. No grammar errors. Text is in authors' own words.	Few spelling errors. Few grammar errors. Text is in authors' own words.	Some spelling errors. Some grammar errors. Text is in authors' own words.	Some spelling errors. Some grammar errors. Most of text is in authors' own words.	Many spelling and or grammar errors. Text is copied.

PRACTICE (20 MINS)

Café Conversations

1. Continue further discussions on topics presented. Understanding the past requires students to develop an awareness of different perspectives. The Café Conversation teaching strategy helps students practice perspective-taking by requiring students to represent a particular point-of-view in a small group discussion. During a conversation, students become more aware of the role many factors play (i.e. social class, occupation, gender, age, etc) in terms of shaping one's attitudes and perspectives on historical events.
2. Expand further the discussion including the themes of life and how living things interact with each other and with their environment; Give students the themes of life then from there expound further by asking them to give examples for every theme cited. Discuss the unifying themes of life and how they are interconnected.

Themes on life:

- a. New Properties Emerge at Successive Levels of Biological Organization
- b. Life's Processes Involve the Expression and Transmission of Genetic Information
- c. Life Requires the Transfer and Transformation of Energy and Matter
- d. From Ecosystems to Molecules, Interactions Are Important in Biological Systems
- e. Evolution (the Core Theme of Biology)

ENRICHMENT (10 MINS)

Close Reading Protocol

1. Ask students to further read (close reading) on the topic which they find very interesting out of the topics raised and discussed.
2. Close reading is carefully and purposefully reading and *rereading* a text. It's an encounter with the text where one focus on what the author has to say, what the author's purpose is, what the words mean, and what the structure of the text tells us. Close reading ensures that student really understand what they have read.
3. Allow students to carefully investigate texts and make connections to essential questions about conditions on early Earth that made the origin of life possible, the first life forms and themes of life.
4. This tool will prepare students to write an essay about a specific topic they like most. Ask students to submit the essay the following meeting,

Teacher Tip:

Refer to Campbell Biology.10th edition. San Francisco, California, USA: Pearson Education Inc.; 2014. Chapter 1: Inquiring about Life

EVALUATION (5 MINS)

Self and Peer Assessment

Students should be provided with opportunities to assess their own learning (self-assessment) and the learning of others (peer assessment). Students can compare their work and provide each other with feedback (peer assessment). Remind students to make specific suggestions and recommendations and what could be improved. Ask for difficulties they encountered and strategies used to make the task easy.

Lesson 26: Bioenergetics Structures and Functions of Cells

Content Standard

The learners demonstrate an understanding of the cell as the basic unit of life, the different cell organelles, and their functions.

Performance Standards

The learners shall be able to differentiate prokaryotic from eukaryotic cells, enumerate cell structures/organelles and describe their functions, and identify which structures are unique to plant cells, animal cells, and bacteria.

Learning Competency

The learners shall be able to explain how cells carry out functions required for life. **(S11/12LT - IIBd - 4)**

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Describe the difference between prokaryotic and eukaryotic cells
2. Explain the functions of various cell structures/organelles
3. Enumerate structures unique to plant cells/animal cells/bacteria
4. Discuss the functions of cytoskeleton and extracellular components

LESSON OUTLINE

Introduction	Communicating learning objectives	15
Motivation	Recall characteristics of life	15
Instruction	Lecture	90

Practice	Drawing Activity	20

Enrichment	Quiz	10

Evaluation	Assignment	50

Materials

Pictures / images of cell organelles; writing and drawing materials; Manila paper; Computers

Resources

- (1) Johnson, G.B. and P.H. Raven, 1996. Biology: Principles and Explanation-Austin, USA: Holt, Rinehart, and Winstin.
- (2) Reece, JB, Urry, LA, Cain ML, Wasseman, SA, Minorsky, PV and RB Jackson, Campbell Biology . Tenth Edition. Boston, USA: Pearson Education, Inc.
- (3) Starr, C and R Taggart. Biology and the Diversity of Life. Tenth Edition, Australia: Thomson - Brooks/Cole. page 233

INTRODUCTION (15 MINS)

Communicating learning objectives

1. Review the previous lesson on the chemical origin of life/first cells
2. Describe the lesson objectives and present the topic outline on the board as follows:
 - a. The cell membrane
 - b. Parts of a typical prokaryotic cell and plant/animal cell
 - c. Common structures in plant and animal cells
 - d. Structures found only in plant and animal cells
 - e. The cytoskeleton and extracellular components

Teacher Tip:

Some specialized structures may be mentioned like cilia, microvillus for animal cells and root hair for plant cells.

Misconception

The flagella can be found both in bacteria, and some eukaryotes such as protists (Euglena). The wave like motion is similar to that of the sperm cell tail.

MOTIVATION (15 MINS)

Recall characteristics of life

1. Ask students the levels of organization in biology: from the organism down to cells and molecules
2. Ask volunteers to enumerate organelles found in plant cells or animal cells
3. With a show of hands, ask the class what cell structure is commonly found in plant cells
4. Show pictures of a bacterial cell and plant cell as seen in college textbooks. Point out some similar structures (Sample response: cell wall; ribosome; cell membrane)

Teacher tip:

The “typical cell” exists only in textbooks for instruction purposes. Given a plant cell as a major type or class of cell, there are numerous variations as to size, shape, and function(s). These depend on the developmental stage of the cell and its metabolic activities.

INSTRUCTION (60 MINS)

1. Describe using illustrations the organization, structure and function of the following:
 - a. The cell membrane
 - i. phospholipids and proteins in membrane
 - ii. the fluid mosaic model of cell membrane
 - b. Parts of a typical bacterial cell; cell membrane; cell wall; ribosome; nucleoid; mesosome; pili; fimbriae; flagella; capsule; cytosol
 - c. Common structures in plant and animal cell: nucleus (with nucleolus); rough endoplasmic reticulum (rER); smooth ER; Golgi complex; lysosomes; ribosomes; micro bodies; mitochondria

- d. Unique structures in plant and animal cells
 - i. found in plants only – chloroplast; cell wall; large vacuole
 - ii. found in animal cells only – centrioles and cilia
- e. The cytoskeleton and some related structures
 - i. microfilaments; intermediate filaments; microtubules
 - ii. centrioles
 - iii. cilia and flagella
- f. Extracellular components
 - i. in plants – cell walls; plasmodesmata
 - ii. in animals – extracellular matrix (ECM); cell junctions – tight junction; desmosome; gap junction

Teacher Tip:

Let the students imagine the structures in 3D. Tell them that what are shown in textbooks are images based on very thin sections of parts of organelles using the electron microscope.

In the absence of a computer or LCD projector, use of big visual aids in Manila paper or cartolina are encouraged.

PRACTICE (20 MINS)

Drawing Activity

- Individually or in groups, students may be asked to draw a typical plant or animal cell as seen in college textbooks. Drawings should clearly reflect the fine structure of the organelles as seen in the electron microscope.
- Each structure in #1 above should be labeled properly.
- With a red ball pen, show the flow of membranes from the outer nuclear envelope to the rough and smooth ER to the Golgi complex and to other micro bodies.
- Ask students what will happen if any organelle is damaged or become defective.

Teacher Tip:

This is the “typical cell” which shows almost all the major organelles in the cytoplasm.

ENRICHMENT (10 MINS)

Quiz

A simple analysis of "odd one out". Identify the structure which does not belong to the group.

1. capsule; flagella; pili; nucleoid; desmosome;
2. cell membrane; DNA; ribosome; peroxisome; cytosol
3. cell wall; plasmodesma; huge vacuole; chloroplast; ribosome
4. lysosomes; nucleus; mitochondria; chloroplast
5. cilia; flagella; centrioles; ER; microtubules

Match: Choose an answer from the choices before each numbered item

- A. ribosomes B. pili C. peroxisomes D. chromoplasts E. gap junctions
6. contain oxidases and catalases
 7. provide cytoplasmic channels from one cell to another
 8. sites of protein synthesis
 9. plastids containing pigments other than chlorophyll
 10. allow bacteria to exchange DNA during conjugation

EVALUATION (20 MINS)

1. As quiz or take home assignment, require the students to make a table showing which structures are unique to bacterial cells and plant cells. In another table, indicate which structures/organelles are common between plant and animal cells and opposite each item, write the function for each particular structure/organelle
2. In class, ask the students (by group) to construct a three-dimensional model of a plant or animal cell. Use materials that can be recycled and are biodegradable.

Answer Key

1. **Desmosome**- found only as an intercellular junction in animal cells; all the rest are found in a prokaryotic cell
2. All the other structures are common to all cells(prokaryotic, eukaryotic) except the **peroxisome** which is found only in eukaryotes
3. **Ribosome** is common to all cells while the other structures are found in plant cells
4. **Lysosomes** are surrounded by a single membrane layer while the rest are made of two layers of membranes
5. **ER**- consists of a membrane layer and the rest are made of microtubules
6. Peroxisomes
7. Gap junctions
8. Ribosomes
9. Chromoplasts
10. Pili

Lesson 27: Bioenergetics

Photosynthesis and Energy Flow

Content Standard

The learners demonstrate an understanding of energy flow and transformation; how autotrophs capture the energy of the sun and convert it to chemical energy

Performance Standards

The learners shall be able to recite the events in photosynthesis, explain how CO₂ is transformed into sugars, and make a poster that illustrates "division of labor" in chloroplasts.

Learning Competencies

The learners shall be able to explain how photosynthetic organisms use light energy to form energy-rich compounds. They will be able to trace the energy flow from the environment to cells. **S11/12LT - IId - 5 and S11/12LT - IId - 6**

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Review the forms of energy
2. Describe the first two laws of thermodynamics
3. Differentiate the nature of enzyme activity
4. Explain photosynthesis as a re-dox process
5. Diagram the events in light reactions
6. Illustrate the Calvin cycle

LESSON OUTLINE

Introduction	Communicating learning objectives	10
Motivation	Inquiry-based Activity	10
Instruction	Lecture	90
Practice	Experiment	20
Enrichment	Quiz	15
Evaluation	Assignment	55

Materials

Writing and drawing materials; pictures and diagrams of chloroplasts; reactions in photosynthesis

Resources

- (1) Johnson, G.B. and P.H. Raven, 1996. Biology: Principles and Explanation-Austin, USA: Holt, Rinehart, and Winstin.
- (2) Reece, JB, Urry, LA, Cain ML, Wasseman, SA, Minorsky, PV and RB Jackson, Campbell Biology . Tenth Edition. Boston, USA: Pearson Education, Inc.
- (3) Starr, C and R Taggart. Biology and the Diversity of Life. Tenth Edition, Australia: Thomson - Brooks/Cole. page 233

INTRODUCTION (10 MINS)

Communicating learning objectives

1. Review the functions of the various cell organelles
2. Describe the lesson objectives and present the topic outline on the board:
 - a. Forms of energy and the laws of thermodynamics
 - b. Metabolic reactions
 - c. Enzymes as catalysts
 - d. Photosynthesis
 - i. light reactions
 - ii. dark reactions

MOTIVATION (10 MINS)

Inquiry-based Activity

1. Ask the students what will happen if the sun will not shine for two months
2. Allow students to recite what are the energy reserves on earth
3. Ask students to imagine if there are no plants on earth
4. Show pictures how solar energy strikes the earth and explain how light energy is converted to chemical energy in photosynthesis

INSTRUCTION (90 MINS)

1. Give a lecture – discussion, with illustrations on the following topics:
 - a. Forms of energy: potential; kinetic; thermal; solar; chemical; mechanical
 - b. Laws of Thermodynamics
 - a. Energy can neither be created nor destroyed; it can only be converted from one form to another.
 - b. Entropy or disorder occurs for every energy transformation.
 - c. Exergonic and endergonic reactions
 - a. Exergonic reactions occur with the net release of free energy.
 - b. Endergonic reactions (“energy inwards”) require free energy from its surroundings.

Teacher Tip:

The terms used even in textbooks may be confusing to the students. Explain that the dark reactions in photosynthesis may occur with or without light.

Misconception:

Dark reactions also occur during daytime.

Teacher Tip:

This portion can be done by recitation. Everyone must be given a chance to voice out their opinion/imagination.

Teacher Tip:

This portion can be done by recitation. Everyone must be given a chance to voice out their opinion/imagination.

Teacher Tip:

Potential energy is stored energy while kinetic is energy in motion that allows some work to be done. Solar, chemical, mechanical are some ways by which energy can be converted from one form to another.

- d. Enzymes as biological catalysts
 - i. Components of an enzyme – apoenzyme; holoenzyme; cofactors; coenzymes
 - ii. Enzyme inhibition – competitive vs. non-competitive
- e. Photosynthesis
 - i. Parts of the chloroplast
 - ii. Splitting of water in photosynthesis
 - iii. Nature of sunlight
 - iv. Linear and cyclic electron flow
 - v. Chemiosmosis
 - vi. Calvin Cycle

Teacher Tips:

- If computers and internet connection are available, videos from the internet on the topics discussed may be shown.
- Enzyme inhibition may be demonstrated by a simple choreography.
- Use visual aids all the time.

PRACTICE (20 MINS)

Experiment

1. Ask students to prepare soil pots with growing mongo plants under normal sunlight. Observe what will happen if some plants are transferred to:
 - a. a shady area
 - b. inside a classroom
 - c. a dark room
2. Keep one or two pots under the sun. All conditions for plant growth should be kept constant except exposure to different “light” or “dark” areas. Record observations on the growth of the plants. Measure the plant height every two days.
3. With paper and pen, ask students to:
 - a. Show the splitting of water in photosynthesis
 - b. Draw the electromagnetic spectrum
 - c. Draw a photosystem as it harvests light in the thylakoid membrane
 - d. Illustrate the light reactions in photosynthesis
 - e. Diagram the Calvin cycle

Teacher Tip:

This is the “typical cell” which shows almost all the major organelles in the cytoplasm.

ENRICHMENT (15 MINS)

Quiz

Directions: True or False. Write T if the statement is correct or true; if not write F.

1. Bioenergetics is the study of how energy flows through living cells.
2. Potential energy cannot be converted to kinetic energy.
3. The energy of the universe is constant.
4. An endergonic reaction is a downhill process.
5. Enzymes catalyze reactions by speeding up energy barriers.
6. Non competitive inhibitors compete with the substrate for the enzyme active site.
7. The oxygen given off by plants come from water, not from CO₂
8. In the electromagnetic spectrum, UV light drives photosynthesis.
9. Cyclic electron flow produces NADPH.
10. Glucose is produced directly from the Calvin cycle.

Answer Key

1. T
2. F
3. T
4. F
5. F
6. F
7. T
8. F
9. F
10. F

EVALUATION (55 MINS)

1. As an assignment and in groups, ask the students to make a poster on:
 - a. Forms of energy
 - b. How enzymes work
 - c. Linear and cyclic electron flow
 - d. Calvin cycle – which reactions require ATP and NADPH

Lesson 28: Bioenergetics

Utilization of Energy

Content Standard

The learners demonstrate an understanding of how organisms obtain and utilise energy.

Performance Standard

The learners shall be able to make a poster that shows the complementary relationship of photosynthesis and cellular respiration.

Learning Competencies

The learners describe how organisms obtain and utilise energy. They also recognise that organisms require energy to carry out functions required for life.

S11/12LT-IIbd-7 and S11/12LT-IIbd-8

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Enumerate the stages of cellular respiration
2. Identify the requirements and products of each stage in the process of breakdown of molecules from glucose to carbon dioxide and water
3. Explain the major stages of cellular respiration
4. Discuss how ATP is used by cells
5. Describe the relationship of photosynthesis and cellular respiration

LESSON OUTLINE

Introduction	Communicating learning objectives	5
Motivation	Inquiry-based Activity	10
Instruction	Lecture	135

Practice	Experiment	15

Enrichment	Class Presentation	45

Evaluation	Quiz	40

Materials

Diagrams and illustrations of the different stages of cellular respiration

Resources

- (1) Brooker, J., EP Widmaier, LE Graham, PD Stiling. Biology. 2008. New York: McGraw Hill. pp 125-150
- (2) Reece, JB., LA Urry, ML Cain, S Wasserman, PV Minorsky, RB Jackson. Campbell Biology. 9th ed. 2014. Illinois: Pearson Education Inc. pp. 141-209
- (3) Russell, PJ., SL Wolfe, PE Hertz, C Starr, B McMillan. Biology: The Dynamic Science. 2008. California: Brooks/Cole CENGAGE Learning.

INTRODUCTION (5 MINS)

Communicating learning objectives

1. Let your students recall that energy from sunlight is transformed to chemical energy stored in macromolecules such as sugars through the process of photosynthesis.
2. For this lesson inform your students that they will learn how the energy stored in sugars is used to produce ATP which is the energy currency of the cell.

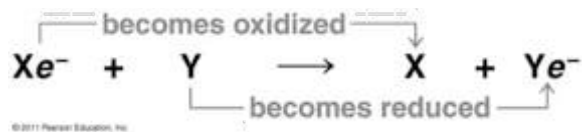
MOTIVATION (10 MINS)

Inquiry-based Activity

1. Ask your students the following:
 - a. what they ate for breakfast or lunch
 - b. what activities they performed after eating breakfast or lunch
2. Let them recite their answers.

INSTRUCTION (135 MINS)

1. Discuss that cellular respiration is a catabolic pathway
 - a. Catabolic pathways – release energy by breaking down complex molecules to simpler compounds; ex. glucose broken down to CO₂ and H₂O
2. Review what reduction – oxidation (redox) reactions are
 - a. Reduction – gain of electrons
 - b. Oxidation – loss of electrons
3. You may use the following diagram:



Teacher Tip:

For the Introduction, you have to let your students see the bigger picture.

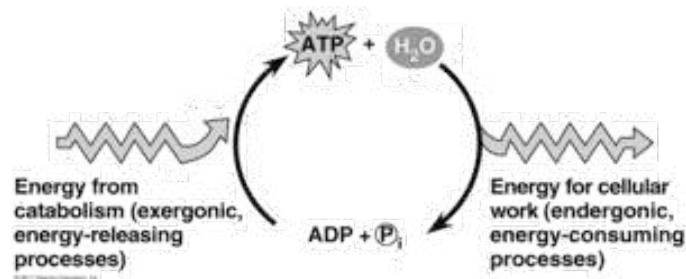
Teacher Tip:

The students should be able to recognize that they obtain energy from the food they eat and the energy is used up by the body to perform work.

Teacher Tips:

- A review of the definitions of catabolic reactions and redox reactions will be helpful in the understanding of cellular respiration. The different stages of cellular respiration are mostly comprised of series of redox reactions.
- For easier understanding and appreciation of your students, the lecture should definitely include the use of illustrations or diagrams of the different steps or stages of cellular respiration. These diagrams can be found in any General Biology book.

4. Describe the nature of ATP. You may use the following diagram to do this.



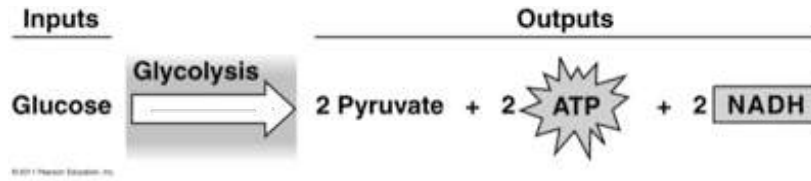
Teacher Tip:

The topic on the different steps of cellular respiration is itself not an easy subject matter to understand. It will be best to enjoin your student to actively participate during the discussion. Ask them drill questions during the discussion and let them ask questions. You may also need to repeat some points for emphasis.

5. Give examples of the different types of cell work which all require energy in the form of ATP
- mechanical – beating of cilia; contraction of muscle cells; cytoplasmic flow
 - transport – active transport
 - chemical – synthesis of polymers from monomers
6. Give an overview of the three major stages of cellular respiration and mention that they should occur in the given order.
- Glycolysis is the breakdown of glucose to pyruvate where small amounts of ATP are produced. This process occurs in the cytoplasm of the cell.
 - Citric acid cycle or tricarboxylic acid cycle or Krebs cycle degrades pyruvate to carbon dioxide, water, ATP and reducing power in the form of NADH, H⁺. This stage happens in the matrix of the mitochondria.
 - Oxidative phosphorylation which includes electron transport chain and chemiosmosis generates high amounts of ATP. This stage occurs in the inner membrane of the mitochondria.
7. Discuss glycolysis in more detail
- Describe the ten steps. You may also give the enzyme that catalyzes each step.
 - A molecule of six-carbon glucose is broken down into two molecules of three-carbon pyruvate.
 - Point out that ATP is required in the first and third steps for a total of 2 ATP.

- d. Explain that for every glucose molecule that is broken down, four ATP molecules are produced via substrate level phosphorylation. Two molecules are produced from step 7 and two more from step 10. The net ATP produced is 2.
- e. Show that two molecules of NADH, H^+ are produced from step 6.

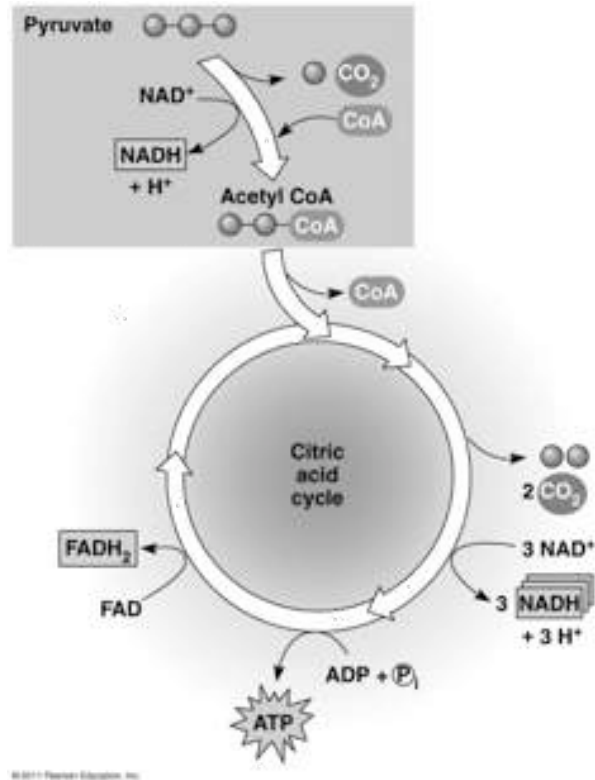
8. Summarize glycolysis by showing this diagram:



9. Discuss citric acid cycle in more detail

- a. Describe the oxidation and decarboxylation of pyruvate producing acetyl CoA and CO_2 . This step also produces NADH, H^+ . For every pyruvate, one molecule of CO_2 , one molecule of acetyl CoA and one molecule of NADH, H^+ are produced.
- b. Acetyl CoA enters the citric acid cycle. Describe the eight steps. You may also give the enzyme that catalyzes each step.
- c. Show that NADH, H^+ are produced from steps 3, 4 and 8; $FADH_2$ is produced from step 6 and ATP from step 5.
- d. Show that CO_2 is released from steps 3 and 4.
- e. Explain that for every acetyl CoA that enters the cycle, three molecules of NADH, H^+ , one molecule of $FADH_2$, one molecule of ATP, and two molecules of CO_2 are produced.

10. Summarize citric acid cycle by showing this diagram:



11. Discuss oxidative phosphorylation in more detail

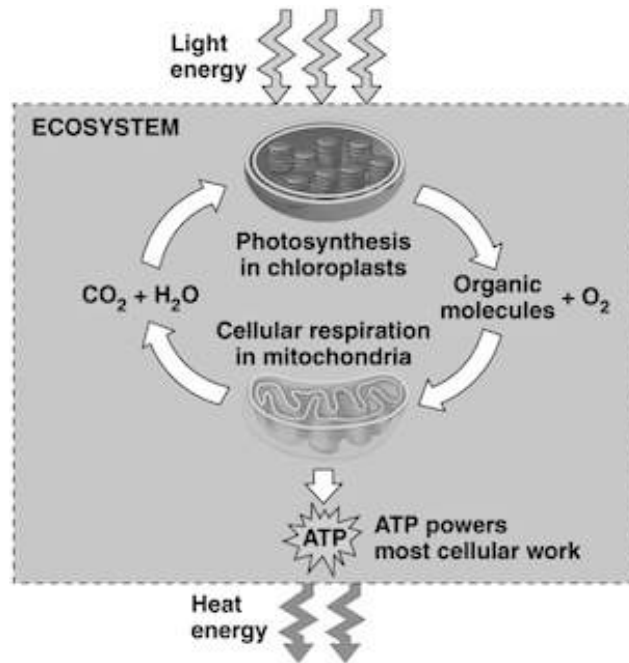
- Describe the electron transport chain. Show that the electrons from the oxidation of NADH , H^+ are passed from one electron carrier to another in the electron transport chain.
- Emphasize that the NADH , H^+ and FADH_2 produced from the previous stages are the electron donors in this stage and that the final electron acceptor is oxygen.
- Describe that ATP is produced by ATP synthase via chemiosmosis.
- Discuss that for every molecule of NADH , H^+ which is oxidized via oxidative phosphorylation, three molecules of ATP are produced and that for every molecule of FADH_2 , two molecules of ATP are produced.

12. Summarize cellular respiration by discussing its general equation:



The six-carbon sugar such as glucose is oxidized and oxygen is reduced forming carbon dioxide, water and energy.

13. Discuss the relationship of photosynthesis and cellular respiration. You may use the following diagram to emphasize the relationship of these two major cellular processes.



14. The cellular respiration process that has so far been discussed involves oxygen, thus it is also referred to as aerobic respiration. But you may also discuss that some cells are capable of producing ATP in the absence of oxygen through fermentation or anaerobic respiration.

There are two types of fermentation process:

- a. **ethanol fermentation** – pyruvate from glycolysis loses carbon dioxide and is converted to two-carbon compound acetaldehyde which is then reduced to ethanol; this step also produces NADH, H⁺. Wine is produced by some bacteria through this process.
- b. **lactic acid fermentation** – pyruvate from glycolysis is reduced to lactate coupled with the oxidation of NADH, H⁺. When oxygen is scarce, human muscle cells may switch to anaerobic respiration leading to the accumulation of lactate.

PRACTICE (15 MINS)

Experiment

1. Show the simple equation for cellular respiration.



2. Ask the students the following questions: Considering one molecule of glucose
 - a. How many pyruvate molecules are produced?
 - b. How many CO₂ are released from the oxidation of pyruvate?
 - c. How many acetyl CoA will enter the citric acid cycle?
 - d. How many CO₂ are released from the citric acid cycle?
 - e. Total number of CO₂ released from the oxidation of one molecule of glucose?
3. You may extend the questions further by giving other numbers of glucose as the starting material; e.g. with three glucose molecules, what is the total number of pyruvate molecules are produced; total number of CO₂ released from glycolysis; total number of acetyl CoA that will enter the citric acid cycle; CO₂ released from citric acid cycle; total number of CO₂ released from the oxidation of three molecules of glucose.

Teacher Tip:

Your students should be able to understand at least how the six molecules of carbon dioxide are derived from one molecule of glucose or hexose sugar. Theoretically, you may give any number of glucose as the starting material to drill them on this general equation of cellular respiration.

ENRICHMENT (45 MINS)

Class Presentation

1. Divide the class into three groups. Assign (or draw lots) the three major stages to each group. Each group will have a discussion and has to think of an analogy of the stage assigned to them. The analogy could be like an everyday story. It could be a story of love, friendship, family, war, peace or even of current events.

2. Ask your students to present their analogy/story to the class for five minutes each group. They should indicate how the story is parallel or analogous to the stage of cellular respiration.

EVALUATION (40 MINS)

Quiz

Here are sample questions on this topic:

1. The following are the different stages of cellular respiration except
 - A. Calvin cycle
 - B. citric acid cycle
 - C. glycolysis
 - D. oxidative phosphorylation
 - E. oxidation and decarboxylation of acetyl CoA

2. The following is(are) true of glycolysis
 - A. Glycolysis is the breakdown of six-carbon glucose to two molecules of three-carbon pyruvate.
 - B. Glycolysis produces a net total of four molecules of ATP via substrate level phosphorylation and two molecules of NADH, H⁺.
 - C. Glycolysis occurs in the mitochondrial matrix.
 - D. A and B are correct.
 - E. A, B, and C are correct.

Answer Key

1. A
2. D
3. E
4. E
5. C
6. E

3. Citric acid cycle produces
- A. ATP
 - B. NADH, H^+
 - C. CO_2
 - D. A and B only
 - E. A, B, and C
4. The electron donor(s) during oxidative phosphorylation is(are)
- A. ATP
 - B. $FADH_2$
 - C. NADH, H^+
 - D. A and B
 - E. B and C
5. The final electron acceptor during oxidative phosphorylation is
- A. AATP
 - B. carbon dioxide
 - C. oxygen
 - D. NADH, H^+
 - E. $FADH_2$
6. ATP as the energy currency of the cell is used in the following
- A. synthesis of polymers from monomers
 - B. active transport
 - C. beating of cilia
 - D. contraction of muscle cells
 - E. all of the above

Lesson 29:

Perpetuation of Life

Content Standard

The learners demonstrate an understanding of plant and animal reproduction; how genes work; and how genetic engineering is used to produce novel products.

Performance Standard

The learners shall be able to conduct a survey of products containing substances that can trigger genetic disorders such as phenylketunaria.

Learning Competency

The learners describe the different ways of how plants reproduce

(S11/12LT-Ilej-13)

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Identify the different ways how plants reproduce.
2. Differentiate asexual reproduction from sexual reproduction.
3. Learn the advantage and disadvantage of both types of reproduction.
4. Relate how the different types of reproduction are being used in farming practices in the Philippines

LESSON OUTLINE

Introduction	Communicating Learning Objectives	5
Motivation	Bringing samples of vegetables and fruits	10
Instruction	Identifying plant samples to plant organs	40
Practice	Relating plant organ samples to plant reproduction	15
Evaluation	Quiz	20
Reflection	End of topic questions	

Materials

Plant samples

Resources

- (1) Reece JB, Urry LA, Cain ML. 2010. Campbell Biology 10th. San Francisco(CA):Pearson Benjamin Cummings; 2010. pp. 815-835
- (2) <http://leavingbio.net/vegetativepropagation.htm>

INTRODUCTION (5 MINS)

Communicate Learning Objectives

1. Introduce the learning objective by writing it on the board, then give the students 5 minutes to write down on a piece of paper what they already know or what they expect to learn under the specified topics:
 - a. Identify the different ways how plants reproduce.
 - b. Define pollination and its importance on fertilization and reproduction.
 - c. Differentiate asexual reproduction from asexual reproduction.
 - d. Learn the advantage and disadvantage of both types of reproduction.
 - e. Relate how the different types of reproduction are being used in farming practices in the Philippines

Teacher Tip:

Through this introduction, you will have an idea where to start or how you will approach your discussion. This will give you an idea where to mainly focus on the given topics to properly managed your time.

MOTIVATION (10 MINS)

Activity: Bahay Kubo Song

1. Beforehand, assign the students to bring representative sample of the different plants from the song Bahay Kubo. The student can bring real plant parts, pictures, drawings, etc. to be identified with the different plants from the song.
2. Group the class into groups with six members, assigning remaining students equally to the formed groups. Each group should have a sample of all the plants in the song. Identify the sequence of participation of the groups, by their numbers (i.e. group 1 goes first, last group the last), through the length of a stick or in any which way the teacher choose to identify the sequence.
3. The teacher starts the activity by singing the first line of the song and pointing to particular group to identify the plant in the song. A member of the group should say the plant and show his/her sample of that plant. The next group in the sequence will then identify the next plant in the song by saying/singing the plant and showing it. The song is continued until a group is not able to identify the next plant in the song.
4. If a group is not able to identify the plant within three seconds, they are eliminated from the game. The group that is left in the game wins. The activity is repeated until a winner is determined. The teacher can give bonus points, recitation points based on how the groups faired in the game.

Teacher Tip:

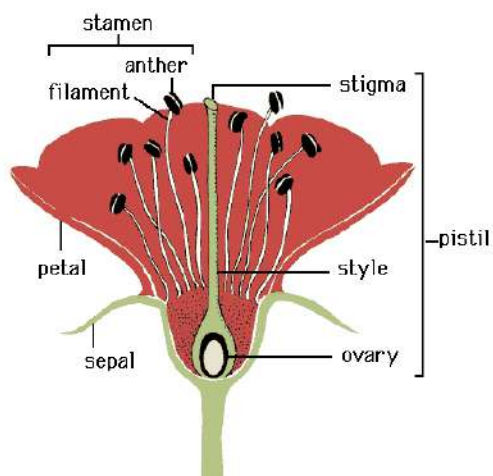
The teacher can do a practice game in order to prepare the students. The teacher can also bring samples of all the plants so that he/she can join the game anytime. This can prevent the groups from guessing and preparing for their answer.

INSTRUCTION/DELIVERY (40 MINS)

REPRODUCTION is one of the characteristics of life. It is a biological process in which new individual organisms are produced, may it be sexual or asexual. Sexual reproduction involves the union of gametes (egg cell and sperm cell) through fertilization. Meanwhile, asexual reproduction involves the creation of cloned offspring from a parent organism.

SEXUAL REPRODUCTION

In plants, flowers play a major role in sexual reproduction as it houses the structures for this process. Below is the picture of a flower and the structures involved directly/indirectly in sexual reproduction.



In many ways, this idealized structure of a flower is found in plants, which employ sexual reproduction. It is composed of four main flower organs: **Stamen and Carpel (Reproductive) and Petals and Sepals (Sterile)**. These organs are held by a structure called a **receptacle**. The **stamen** is male reproductive organ, which produces the **pollen**, which contains the **sperm cell**. Meanwhile, the **carpel** or the female reproductive organ has the following structures: **stigma, style and ovary**. The **stigma** is the sticky end of the carpel where pollen is trapped during the process of **pollination**. The style is a slender neck where the sperm cell from the pollen can travel to the base of the carpel called the **ovary**. In the ovary are **ovules**, female gametes, which when is fertilized by the sperm becomes the seeds of a **fruit**. Sometimes, a flower has only one carpel, or has more than one carpel, which is fused, it is called a **pistil**.

Teacher Tip:

The new terms in the lesson proper should be addressed first, either as an assignment for recitation or as another activity to lessen banking of terms. Even if the lesson calls for a lot of familiarization, dialogical discussion can occur if the students are equipped beforehand of the topic to be studied.

Source

Parts of a Flower. <http://vignette1.wikia.nocookie.net/analytical/images/2/23/Pistil.gif/revision/latest?cb=20100120062519>

Pollination is the process of transferring pollen from an anther to a stigma. There are various ways in which pollination occurs whether through self-pollination, wherein the pollen is transferred to the stigma of a plant's own flower, or cross-pollination wherein pollen from a different plant is delivered to a stigma of a flower of a different plant. Pollination is needed in order for fertilization to occur. Compared to self-pollination, cross-pollination can increase genetic diversity of plants as genes from two different individuals are shared by the offspring.

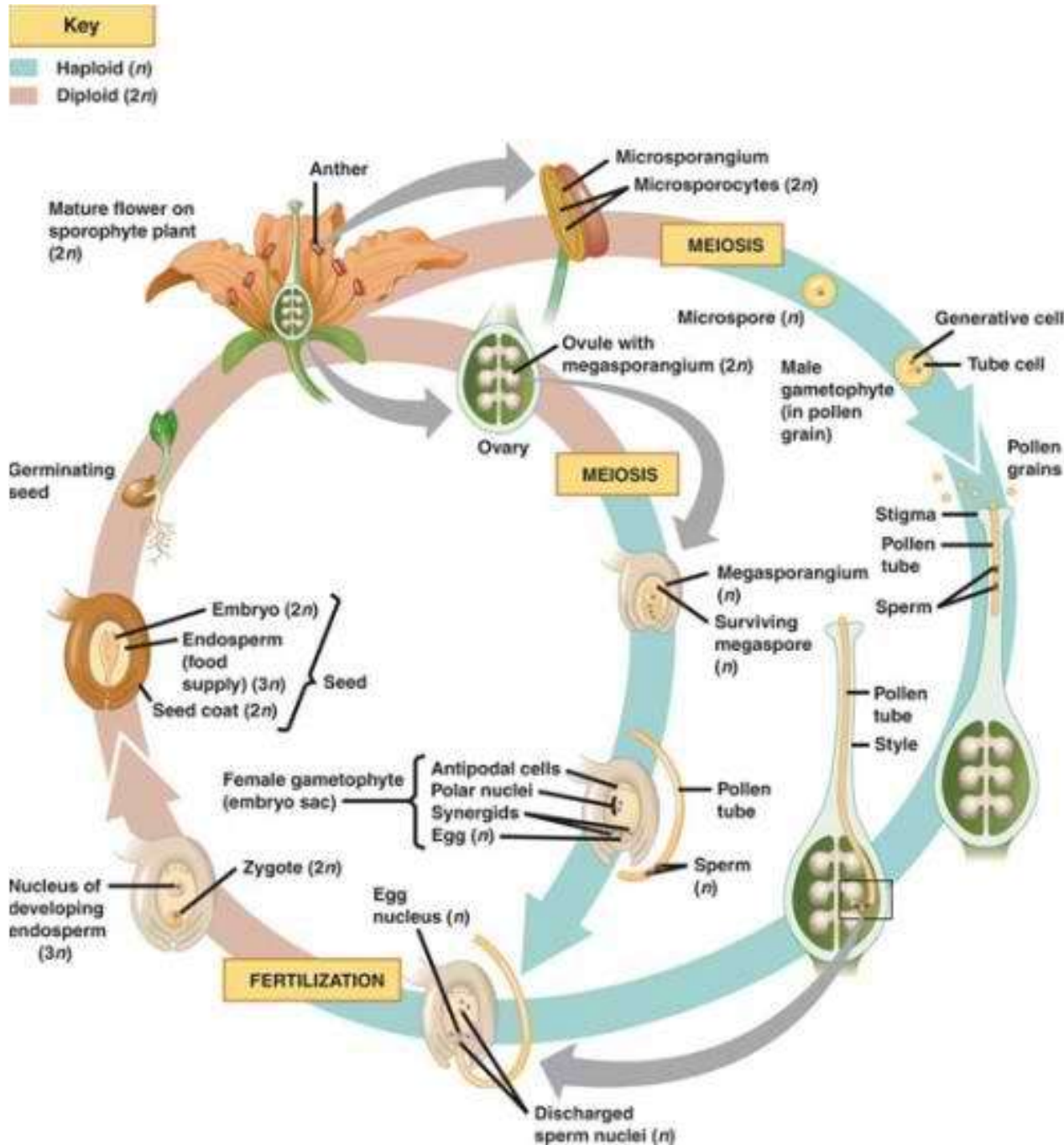
There are different methods on how pollen is transferred from one anther to one stigma. Mainly, pollination is through biotic means (80%) and among abiotic methods of pollination, wind (98%) and water (2%) are the main agents.

Biotic Pollinators

- e. **Bees**- rely on nectars from flowers for they food, as such they pollinate flowers with delicate, sweet fragrance. They are also attracted to bright colrs, yellow and blue. Red might be dull to them, but, flowers were able to evolve by creating ultraviolet markings as nectar guides as bees can see ultraviolet light.
- f. **Moths and butterflies** – like bees, detect odors and pollinate flowers with sweet fragrance. The difference in activity of a butterfly and a moth allows pollination of different plants, as butterflies are attracted to bright flowers they are day pollinators while moths, which are mostly active at night, are attracted to white or yellow flowers which are very distinct at night.
- g. **Bats** – like moths are attracted to sweet smelling lightly colored flowers which stand out at night.
- h. **Flies** – are attracted to red, fleshy flowers with a rank odor reminiscent of decaying meat.
- i. **Birds** – do not have a keen sense of smell, thus, flower fragrance is not a flower character trait by plants pollinated by birds. Birds are usually attracted to bright flowers such as red and yellow. Also, their nectar have high sugar content which is needed by birds.

There are other biotic agents of pollination, which aids in the delivery of pollen to a flower's carpel. This organism, as shown above, is adapted to the various characteristics of flowers that require pollination.

After the process of pollination, the process of fertilization might occur, which can result in the development of a seed which houses the embryo of a future plant. Below is the process of gametophyte production, pollination, double fertilization and seed development.



The picture on the left shows the complete process of how a seed is formed, which might eventually become a sexually produced organism.

First, egg cells (1) and sperm cells (2) are developed from particular reproductive organs. Through pollination, two sperm cells are delivered to the ovules which fertilizes an egg cell and the endosperm, creating a process called double fertilization.

The union of the sperm cells and egg cells, which both contains half the genetics materials of the parent, allows the creation of a possible organism with the same set/number of genetic material.

If fertilization is successful, the seed will develop with the corresponding embryo, endosperm and seed coat. It will then be prepared for dispersal and germination.

Source: http://bioweb.uwlax.edu/bio203/2011/ismatull_otab/purple_template/images/Angiosperm

ASEXUAL REPRODUCTION

In plants, as some organs grow indeterminately due to tissues that can actively divide (meristem- actively dividing cells) and revert to non-specialized structures (parenchyma tissues). This indeterminate growth can lead to a form of reproduction called asexual reproduction, as these organs can separate from the parent plant with the ability to grow and develop. Fragmentation, the most common method of asexual reproduction, can occur through growth from a stem, leaf, root and other plant organ which gained the ability comparable to parent plant. Not all asexual reproduction is a product of fragmentation, plants can also produce seeds without the process of pollination and fertilization, called apomixis. Apomixis occurs when diploid cells in the ovule create an embryo, this can later result in the formation of a seed. Furthermore, vegetative propagation and grafting are natural and man-made processes of asexual reproduction. Below are different types of vegetative propagation:

- a. Stems: that grow horizontally above the ground is called a runner. The nodes of these plants can allow asexual reproduction through bud growth. Example of this is grass.
- b. Roots: swollen roots called tubers can allow asexual reproduction. Example of this is the swollen root of a cassava, not that of a potato. Potatoes are stems, as evidenced by their nodes.
- c. Leaves: that are succulent, such as the catatata leaf, can allow asexual reproduction.
- d. Bulbs: such as onion (each skin is a leaf) and garlic (each piece is a modified stem and leaf) is attached to an underground stem. Each can form a new bulb underground.

Artificial propagation

- a. Grafting: is composed of the stock (rooted part of the plant) and the scion (the attached part). This is usually done to hasten the reproductive ability of a plant, grow a selected fruiting plant, etc.
- b. Layering: like what happens to a runner, wherein, a shoot of a parent plant is bent and is covered by soil. This stimulates root growth, after which, the plants can be separated.
- c. Cutting: is done to propagate a plant by cutting the stem at an angle of a shoot with attached leaves. Sometimes, growth stimulator is given.

Advantage and Disadvantage of Both Types of Reproduction

Sexual Reproduction

Advantage

- Genetic variability
- Dispersal
- Large number
- Adapted to unstable and difficult environments
- Growth can be suspended

Disadvantage

- Energy expensive
- Need for a pollinator
- Prone to predation
- Time constraint

Asexual Reproduction

Advantage

- No need for pollinator
- Pass all good genetic material as offsprings are clones of parents
- Can grow rapidly in a stable environment, as the offspring are genetically adapted to the environment
- Strong seedlings, prevents predation
- Energy economical

Disadvantage

- Clones are prone to diseases, predation, etc.
- Cannot be dispersed long distances
- Prone to environmental fluctuating conditions

PRACTICE AND ENRICHMENT (15 MINS)

After the Lesson Proper, in order to evaluate the understanding of the students of the lesson, group the students again using the same grouping during the start of the class. With the plant parts the members brought, ask the group to classify the type of reproduction the sample they brought are under. They can make a table, a skit, a report in classifying their samples either sexually or asexually reproduced. Together with this classification, ask the group if the plant reproduces asexually, what type of asexual reproduction (including vegetative propagation) it employs. Have the group report their findings after five minutes.

EVALUATION (20 MINS)

The teacher can make his/her own list of questions that will allow students to practice critical thinking skills. The quiz can be administered by pairs or individually. Paired or grouped quiz allows the student to further discussed the lesson and learn from their peers. The teacher can formulate open-ended questions or multiple-choice exam from the lesson. The following are guide questions which can help the teachers in formulating their questionnaires.

1. What is the difference between sexual and asexual reproduction?
2. What are the different plant organs responsible for sexual reproduction? for asexual reproduction?
3. What is the importance of the stamen? of the carpel?
4. Describe the process of pollination. How it plays a role in sexual reproduction in plants?
5. What are the different types of pollination? How is one advantageous over the other method?
6. What are the two types of pollinating agents?
7. How are pollinators adapted together with the plant that they pollinate?
8. What is double fertilization?
9. Identify/Illustrate the process of gametophyte production, pollination, double fertilization and seed production.
10. What are the different types of asexual reproduction?
11. Why and how is asexual reproduction possible?
12. How does the ability of a plant to asexually reproduced help farmers in the propagation of their crops?
13. If there is a drought, how does one's knowledge of plant reproduction determine crop yield?

Teacher Tip:

During this time, the teacher should be more of a facilitator to the discussion to help students in looking for the answer to questions or goals of the activity.

14. With your knowledge of pollination, how can the government help farmers adapt to their changing environment, especially with the reality of climate change?
15. How can the government help local farmers from the impacts of globalization (e.g APEC, etc.) with less technology our farmers have compared to other countries?

REFLECTION (HOMEWORK FOR NEXT MEETING)

1. Which of the topics interest you the most? Why?
2. Which of the topics interest you the least? Why?
3. Did the activities help you understand the topic (Y/N)? Explain your answer.
4. Did you see the significance/ connection of the topic in your life?

Lesson 30:

Perpetuation of Life

Content Standard

The learners demonstrate an understanding of plant and animal reproduction, how genes work, and how genetic engineering is used to produce novel products.

Performance Standard

The learners shall be able to conduct a survey of products containing substances that can trigger genetic disorders such as phenylketonuria.

Learning Competency

The learners illustrate the relationships among structures of flowers, fruits, and seeds **(S11/12LT-11ej-14)**

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Recall the function of plant organs in sexual reproduction
2. Learn the structure to function relationship in biological system
3. Relate structure function relationship among flowers, fruits and seeds
4. Identify local plants and how the structure of their flower, fruit and/or seeds are aided in dispersal

LESSON OUTLINE

Introduction	Communicating Learning Objectives	5
Motivation	Bringing everyday tools and their function	10
Instruction	Lesson Proper	40
Practice	Relating the plant organ samples to the type of plant reproduction	
Evaluation	Quiz	20
Reflection	End of the Topic Questions	

Materials

Everyday objects, Plant samples, and school supplies

Resources

- (1) Reece J. B., Urry, L. A., & Cain, M. L. (2010). *Campbell Biology* (10th ed., pp. 815-835). San Francisco, CA: Pearson Benjamin Cummings.
- (2) Vegetative propagation. (n.d.). Retrieved from <http://leavingbio.net/vegetativepropagation.htm>

INTRODUCTION (5 MINS)

1. **Communicate Learning Objectives:** Introduce the following specific topics, then give the students a few minutes to write down what they already know or what they expect to learn under each topic.
 - a. Recall the function of plant organs in sexual reproduction
 - b. Learn the structure to function relationship in biological system
 - c. Relate structure function relationship among flowers, fruits and seeds
 - d. Identify local plants and how the structure of their flower, fruit and/or seeds are aided in dispersal

Teacher Tip:

You can read these topics aloud, or write them down on the board. Through this introduction, you will get an idea of where to start and where to focus your discussion, to properly manage your time.

MOTIVATION (10 MINS)

1. **Activity:** Identifying the function of everyday tools
 - a. Bring an everyday object to class, and describe its appearance and/or structure. Discuss its functions in relation to its description.
 - b. Ask one or more students to do the same.
 - c. If not all students will present their object in class, require them to prepare a short write-up describing the structure and function of their object.

INSTRUCTION/DELIVERY (40 MINS)

In biological systems, there is a distinct relationship between an organism's structure and its corresponding function. This is seen in the moist skin of frogs, which allows it to breathe through its skin. The position of the eyes and nose of a predator functions in order for it to see its prey and acquire the necessary oxygen for energy production. This is also evident in plants: in the branching of roots to anchor large trees, the large number of leaves to acquire more light for photosynthesis, and wood formation for structural integrity. It is further observed in the structure-function relationship in flowers, fruits and seeds, and in the relationships among these structures. This lesson will discuss the individual structure-function relationships of these organs and the structure-function relationship among these organs.

Teacher Tip:

New terms should be introduced and defined before discussing them in greater depth. Students may be given time to prepare by introducing the terms for definition before the lesson, so they can participate more actively in the discussion.

FLOWERS

1. **Review of previous lesson:** Flowers play a major role in sexual reproduction as it houses the structures for this process. Below is the picture of a flower and the structures involved directly/indirectly in sexual reproduction.

2. Vegetative Part

- a. Receptacle – holds the floral parts of the flower
- b. Sepal – modified leaves that protects a flower in bud and holds the petals when in bloom
- c. Calyx – collective term for the sepals
- d. Petal – modified leaves that surround the reproductive organ or plants; normally colourful, and with odor, to attract pollinators
- e. Corolla – collective term for petals
- f. Inflorescence – cluster of flowers

3. Reproductive Part

- a. Stamen – male reproductive organ
- b. Filament – stalk that holds the anther at the end
- c. Anther – produces the pollen which houses the sperm cell
- d. Carpel – Female reproductive organ. Singly or fused, is called a pistil
- e. Style – the slender neck of the carpel which holds the stigma at its end.
- f. Stigma – is a structure with sticky substance which traps pollen
- g. Ovary – the bulbous structure of the carpel which contains the ovule
- h. Ovule – has the egg cell of the plant.

4. Complete vs Incomplete Flower

- a. A complete flower has all the parts described
- b. An incomplete flower is missing one or more parts

5. Adaptive mechanisms

- a. As the flower is important in the development of a fruit and the eventual dispersal of the seed for plant propagation, it has evolved different adaptive mechanisms.
- b. This structure to function relationship is important as the plant should be able to attract specific pollinators to increasing the success rate of its propagation.
- c. Competition among plants over one pollinator may result in lesser chance of propagation.

Teacher Tip:

Some of these adaptive mechanisms have been described and discussed during the last lesson, such as the color and smell of flowers in attracting different types of pollinators.

FRUITS

1. Fruits – structures that not only protect the seeds of plants but also aid in their dispersal; derived from the maturation of a flower's ovary
 - a. The ovary walls eventually become the pericarp during development.
 - b. The pericarp is further divided into three parts: the exocarp or skin, the mesocarp or the flesh and the endocarp, which is the core.
 - c. Depending on fruit adaptations, the pericarp can be stony, woody, fleshy as such the endocarp might not be fleshy, the exocarp might be rubbery or woody, etc.
 - For example: the apple's seed and fruit is protected by an accessory fruit which formed from the fleshy receptacle. This ensures that the seed will not be harmed during the consumption of the fleshy receptacle, as the fruit is not eaten, rather is thrown, aiding in its dispersal. Again, this is an example of a structure function relationship not only in one organ (the fruit) but between the flower and the fruit that was formed.

SEEDS

1. The seed or mature ovules contain the embryo, which will eventually germinate and grow if properly dispersed in a favorable environment.
2. To protect the embryo from harsh environmental conditions, it goes into a state of dormancy until a period for favorable growth and development arrives. The embryo, which is not able to produce its own food yet, is provided with food by the cotyledon or the endosperm, or both.
3. To protect the embryo, the seed coat has an hardened outer covering which protects it from physical or chemical disturbances.
4. The embryo is composed of the hypocotyl or the embryonic axis which terminates to the radicle or the embryonic root and the epicotyl, which is attached to the first, leaves.
5. The young leaves—together with the cotyledon, the epicotyl and the apical meristem (responsible for apical growth or elongation)—is called the plumule.
6. In grass, the embryo is protected by two sheaths: the coleoptile (protects the young shoots) and coleorhiza (protects the young roots).

SEED AND FRUIT DISPERSAL

1. Like pollination in plants, different agents aid seed and fruit dispersal.
 - a. Abiotic agents (wind, water)
 - b. Biotic agents (animals)
2. In order to propagate, plants have evolved in order to adapt to their environments.
 - a. Flowers ensures the formation of the embryo through different adaptations for pollination and fertilization.
 - b. The developing embryo is helped by the adaptation of the fruit and seeds, which further protects and aids in its propagation.

PRACTICE AND ENRICHMENT

Revisit the everyday objects that the students brought to class. Recall the structure-to-function analyses of these objects. Additional points for consideration: if the object is likened to a flower, fruit or seed, what part of that organ is it, and how does it relates to that particular organ's structure and specific function?

EVALUATION (20 MINS)

Administer a quiz to students. The teacher can use the guide questions provided below, or formulate their own questions.

Guide questions:

1. How is structure related to a particular function?
2. Relate specific plant structures to their function/s.
3. How does the structure-function relationship play out in flowers?
4. How does the structure-function relationship play out in fruits?
5. How does the structure-function relationship play out in seeds?
6. How is the structure-function exhibited in local flowers, fruits, or seeds? Give definite examples.
7. Illustrate the functional relationship of flowers, fruits and seeds.
8. Illustrate the structural relationships of flowers, fruits and seeds.

Teacher Tips:

This can be done individually, to allow those who did not recite in the introductory activity to participate. This can also be done in groups, to facilitate peer learning and interaction.

The quiz can be administered individually, in pairs, or in groups. Paired or grouped quizzes allow students to further discuss the lesson and learn from their peers.

The teacher can try formulating open-ended questions or multiple-choice questions.

9. Islands, like in the Philippines, are usually covered by coconuts at the shores. Using your knowledge of plant propagation, explain how/why this happens.
10. How can you prevent the propagation of alien species which can outcompete endemic Philippine plants, using your knowledge of plant propagation?

REFLECTION (HOMEWORK FOR NEXT MEETING)

1. Which of the topics interest you the most? Why?
2. Which of the topics interest you the least? Why?
3. Did the activities help you understand the topic (Y/N)? Explain your answer.
4. Did you see the significance/ connection of the topic in your life?

Lesson 31: Perpetuation of Life

Content Standard

The learners demonstrate an understanding of plant and animal reproduction; how genes work; and how genetic engineering is used to produce novel products.

Performance Standard

The learners shall be able to conduct a survey of products containing substances that can trigger genetic disorders such as phenylketunaria.

Learning Competency

The learners describe the different ways of how representative animals reproduce **(S11/12LT-Ilej-15)**

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Identify the different ways how plants reproduce.
2. Differentiate asexual reproduction from sexual reproduction.
3. Learn the advantage and disadvantage of both types of reproduction.
4. Relate how animal reproduction impacts ecosystem imbalance

LESSON OUTLINE

Introduction	Communicating Learning Objectives	5
Motivation	Recall of plant reproduction	10
Instruction	Lesson Proper	40
Practice	Relating animal reproduction to ecological imbalance	
Evaluation	Quiz	20
Reflection	End of the topic questions	

Materials

Representative animals, School supplies

Resources

(1) Reece JB, Urry LA, Cain ML. 2010. Campbell Biology 10th. San Francisco(CA):Pearson Benjamin Cummings; 2010. pp. 1013-1014.

INTRODUCTION (5 MINS)

Communicate Learning Objectives

1. Introduce the learning objective by writing it on the board, then give the students 5 minutes to write down on a piece of paper what they already know or what they expect to learn under the specified topics:
 - a. Identify the different ways how plants reproduce.
 - b. Differentiate asexual reproduction from sexual reproduction.
 - c. Learn the advantage and disadvantage of both types of reproduction.
 - d. Relate how animal reproduction impacts ecosystem imbalance

Teacher Tip:

Through this introduction, you will have an idea where to start or how you will approach your discussion. This will give you an idea where to mainly focus on the given topics to properly manage your time.

MOTIVATION (10 MINS)

1. The teacher recalls the process of reproduction in plants to the class. A debate on the use of asexual and sexual reproduction in animals will be initiated. Ask the advantage and disadvantage of the two methods in animal reproduction.

Teacher Tip:

The teacher can start the lesson by introducing an everyday tool/object he or she brought in the class and associate it to its corresponding function. This can then be related to the lesson.

INSTRUCTION/DELIVERY (40 MINS)

Like plants, animals need to reproduce in order to increase the chance of the perpetuation of their species. But unlike plants, there is an assumption that animals reproduced only through the process of fertilization, or the fusion of the sperm cell and egg cell. Actually, like plants, some animals also used asexual or sexual or both methods of sexual reproduction.

Sexual reproduction is the process of joining the haploid gametes (sex cells) to form a diploid cell called a zygote. A zygote, eventually becomes an embryo and later on develop into an organism. The female gamete is an egg cell, is usually non-motile, to ensure survival of the embryo by storing energy. The male gamete is a sperm cell, which is motile to search for the egg cell for fertilization. In asexual reproduction, fusion of the egg cell and sperm cell does not occur, reproduction is mainly through mitosis which creates a clone of the parent.

The following are the different methods of asexual reproduction:

1. Budding- occurs when individuals arise throughout the outgrowths from a parent. This can create a colony of individuals attached to a parent, such as in corals.
2. Fission- is the separation/division of an organism to form individuals of approximately same size. This is usually observed in animal-like protists.
3. Fragmentation and Regeneration- fragmentation is when an animal's body breaks into different parts, which later regenerate to form several individuals. Sponges, annelids, cnidarians and tunicates are examples of this mode of reproduction.
4. Parthenogenesis- is like apomixes in plants, where the egg cell develops without fertilization. This is exhibited by bees, wasps, lizards, sharks.

Just like in plant reproduction, sexual reproduction is disadvantageous in terms of energy expenditure but is advantageous due to the genetic variation it creates. It allows organism to perpetuate in an unstable environment where factors such as diseases can decrease the survival rate of the population. Meanwhile, asexual reproduction is a method of reproduction which lessens energy expenditure in animals, as fully formed individuals are produced, increasing the chance of survival.

Teacher Tip:

The new terms in the lesson proper should be addressed first, either as an assignment for recitation or as another activity to lessen banking of terms. Even if the lesson calls for a lot of familiarization, dialogical discussion can occur if the students are equipped beforehand of the topic to be studied.

PRACTICE AND ENRICHMENT

Given the following scenarios, ask the class which method of animal reproduction will best allow the survival of a particular species:

1. In an area devastated by a level 5 Typhoon.
2. Rainforest
3. Dessert
4. After an earthquake
5. Antarctica

EVALUATION (20 MINS)

The teacher can make his/her own list of questions that will allow students to practice critical thinking skills. The quiz can be administered by pairs or individually. Paired or grouped quiz allows the student to further discussed the lesson and learn from their peers. The teacher can formulate open-ended questions or multiple-choice exam from the lesson. The following are guide questions which can help the teachers in formulating their questionnaires.

1. What is the difference between sexual and asexual reproduction?
2. What are gametes? What are the types of gametes?
3. What is a zygote?
4. Give an advantage of sexual reproduction over asexual reproduction?
5. Give an advantage of asexual reproduction over sexual reproduction?
6. What are the different methods of asexual reproduction?
7. What is the prerequisite for binary fission to occur, in terms of an organism's growth?
8. Why is regeneration needed for animals undergoing asexual reproduction through fragmentation?
9. How can invasive species outcompete native species and become a threat through their mode of reproduction?
10. If you are a conservationist, how will you be able to help the proliferation of an animal species through your knowledge of its mode of reproduction?

REFLECTION (HOMEWORK FOR NEXT MEETING)

1. Which of the topics interest you the most? Why?
2. Which of the topics interest you the least? Why?
3. Did the activities help you understand the topic (Y/N)? Explain your answer.
4. Did you see the significance/ connection of the topic in your life?

Lesson 32: Perpetuation of Life

Content Standard

The learners demonstrate an understanding of plant and animal reproduction; how genes work; and how genetic engineering is used to produce novel products.

Performance Standard

The learners shall be able to conduct a survey of products containing substances that can trigger genetic disorders such as phenylketunaria

Learning Competency

The learners explain how the information in the DNA allows the transfer of genetic information and synthesis of proteins **(S11/12LT-Ilej-16)**

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Describe the central dogma.
2. Explain the process of replication.
3. Explain the process of transcription.
4. Explain the process of translation.
5. Synthesize the implication of the central dogma

LESSON OUTLINE

Introduction	Communicating Learning Objectives	5
Motivation	Pamana nina Nanay at Tatay	10
Instruction	Lesson Proper	30
Practice	Identify different implications of the genetic information on traits and disease	10
Evaluation	Quiz	5
Reflection	End of the topic questions	

Materials

Table of codons, school supplies

Resources

- (1) Reece JB, Urry LA, Cain ML. 2010. Campbell Biology 10th. San Francisco(CA):Pearson Benjamin Cummings; 2010. pp. 1013-1014.
- (2) Image from <http://patentimages.storage.googleapis.com/EP0175960B1/imgb0001.png>

INTRODUCTION (5 MINS)

Communicate Learning Objectives

1. Introduce the learning objective by writing it on the board, then give the students 5 minutes to write down on a piece of paper what they already know or what they expect to learn under the specified topics:
 - Describe the central dogma.
 - Explain the process of replication.
 - Explain the process of transcription.
 - Explain the process of translation.
 - Synthesize the implication of the central dogma

Teacher Tip:

Through this introduction, you will have an idea where to start or how you will approach your discussion. This will give you an idea where to mainly focus on the given topics to properly managed your time.

MOTIVATION (10 MINS)

1. The teacher recalls the trait he or she inherited from his or her parents. The inherited trait or “namana” can be physical, talent or behavior. Ask the student the traits they inherited to their parents and show it to the class.
2. Clarify after the activity that within the context of the lesson, the inherited trait that will be discussed are of those physical characters as governed by the proteins in our body.

Teacher Tip:

The teacher can start the lesson by introducing an everyday tool/object he or she brought in the class and associate it to its corresponding function. This can then be related to the lesson.

INSTRUCTION (40 MINS)

The Central Dogma

The central dogma, or the directional command of creating proteins from genetic information (DNA) was dubbed by Francis Crick in 1956. It summarized in a simple illustration below:



Teacher Tip:

The new terms in the lesson proper should be addressed first, either as an assignment for recitation or as another activity to lessen banking of terms. Even if the lesson calls for a lot of familiarization, dialogical discussion can occur if the students are equipped beforehand of the topic to be studied.

Here, the information from the DNA is transcribed into an RNA which is later translated into a protein. The protein produced has implication on a trait inherited or a particular cell function such as in the production inflammatory agents and other protein molecules. The central dogma in prokaryotic and eukaryotic cells do not differ greatly, difference lies mostly in the site of the process and the characteristics of the genetic information.

As shown from the illustration above, the nuclear compartment allows for further processing of the mRNA, which is critical in the creation of proteins. To ensure the constant creation of proteins, whenever the cell or body needs it, the cell should be able to replicate the information which will determine the creation of the protein. DNA replication ensures that the information for a particular protein synthesis will not be lost.

The double helix structure which was discovered by Watson and Crick with the help of X-ray crystallography by Rosalind Franklin allows the efficient replication of DNA, preventing information lost. Different proteins and enzymes help in the process of replication. Once a DNA segment is ready, it will be read and transcribed in the process called translation.

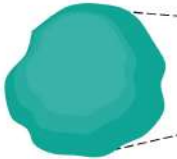
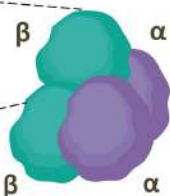
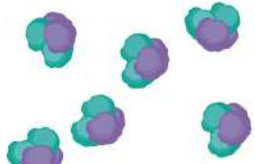
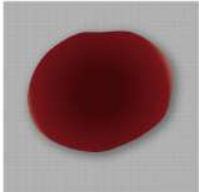
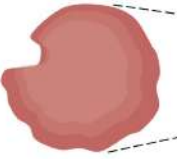
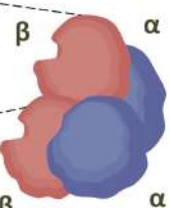
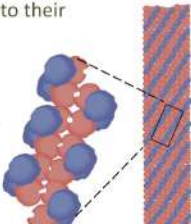
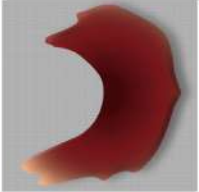
The different DNA sequence characterized by the Nitrogenous bases cytosine (C), guanine (G), thymine(T) and adenine (A) are read and transcribed by different proteins and enzymes. These bases pair together, forming complementary strands of DNA (for Replication) or RNA (for Transcription) In DNA, C-G and A-T form pairs, while in RNA, T is paired to Uracil (U) in its complementary strand.

The process of transcription involves various process of converting DNA segments into RNA, splicing of these segments and joining in order to form an mRNA (or messenger RNA) which will carry the message from the DNA to the ribosome for translation of the message to a particular protein. With the help of a tRNA or a transfer RNA in a ribosome, message carried by the mRNA is translated to particular amino acid sequence which makes a protein.

A codon or a sequence of three DNA or RNA nitrogenous base is the information needed in the creation of an amino acid. The 20 amino acids in the biological systems are created through the different information formed by the sequence of the base pairs, below is a table which shows the different amino acids:

	U		C		A		G	
U	UUU	Phe (F)	UCU	Ser (S)	UAU	Tyr (Y)	UGU	Cys(C)
	UUC		UCC		UAC		UGC	
	UUA	Leu(L)	UCA		UAA	Ocher	UGA	Opal
	UUG		UCG		UAG	Amber	UGG	Trp (W)
C	CUU		CCU	Pro (P)	CAU	His (H)	CGU	Arg (R)
	CUC		CCC		CAC		CGC	
	CUA		CCA		CAA	Gln (Q)	CGA	
	CUG		CCG		CAG		CGG	
A	AUU	Ile (I)	ACU	Thr (T)	AAU	Asn (N)	AGU	Ser (S)
	AUC		ACC		AAC		AGC	
	AUA		ACA		AAA	Lys (K)	AGA	Arg (R)
	AUG	Met (M)	ACG		AAG		AGG	
G	GUU	Val (V)	GCU	Ala (A)	GAU	Asp (D)	GGU	Gly (G)
	GUC		GCC		GAC		GGC	
	GUA		GCA		GAA	Glu (E)	GGA	
	GUG		GCG		GAG		GGG	

Thus, a particular DNA segment has implication on the particular protein which a cell will produce. A problem, such as deletions, insertions or inversions in one or more of the bases in the DNA can change the protein that will be decoded during translation. The case of sickle cell anemia is an example, where,

	Primary Structure	Secondary and Tertiary Structures	Quaternary Structure	Function	Red Blood Cell Shape
Normal Hemoglobin	1 Val 2 His 3 Leu 4 Thr 5 Pro 6 Glu 7 Glu	Normal β subunit 	Normal hemoglobin 	Normal hemoglobin proteins do not associate with one another; each carries oxygen 	Normal red blood cells are full of individual hemoglobin proteins  5 μm
Sickle-cell Hemoglobin	1 Val 2 His 3 Leu 4 Thr 5 Pro 6 Val 7 Glu	Sickle-cell β subunit 	Sickle-cell hemoglobin 	Hydrophobic interactions between sickle-cell hemoglobin proteins lead to their aggregation into a fiber; This reduces their capacity to carry oxygen 	Fibers of abnormal hemoglobin deform red blood cell into sickle shape  5 μm

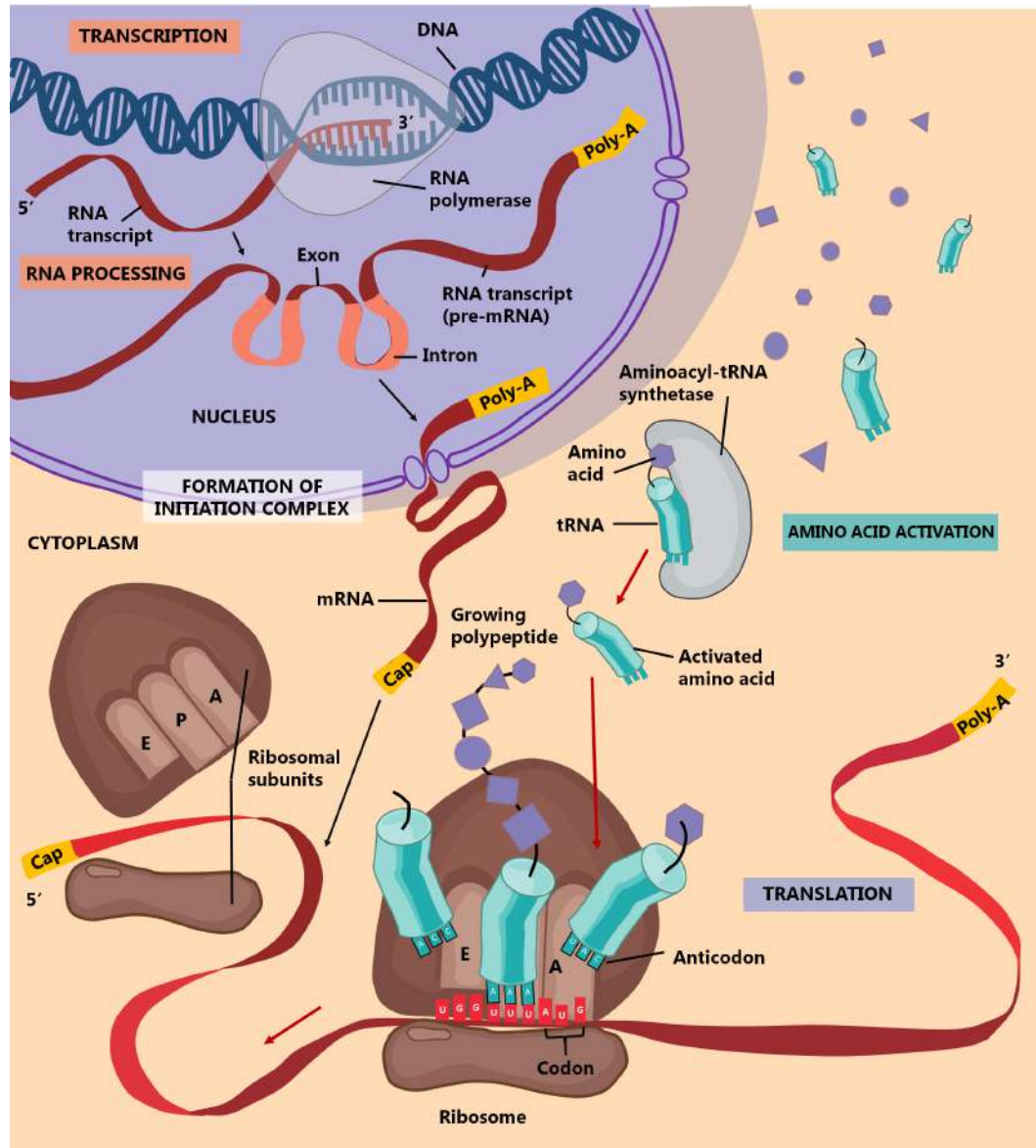
A single amino acid substitution in a protein causes sickle-cell disease.

Connect

Considering the chemical properties of the amino acids valine and glutamic acid, propose a possible explanation for the dramatic effect on protein function that occurs when valine is substituted for glutamic acid.

The illustration shows the great implication of a change in the DNA or genetic information in an organism. Structurally, the red blood cell changed from a donut shape to a sickle-like shape even if only one amino acid was changed. More importantly, a difference in the middle base pair is the culprit in the change in the amino acid which later caused a change in the protein structure. Imagine, huge difference in larger segments in the DNA or RNA sequence exists, what will be its implication on a protein translated? To the organism as a whole?

The synthesis of proteins as shown in the central dogma, is carried by a series of complex processes. These processes have stop gaps to prevent problems from occurring especially in the final translation of the protein. The cell has the ability to terminate the process whenever problems exists, but if this is not prevented certain genetic diseases might occur. Below is a review of the process of protein synthesis:



PRACTICE

1. Group the class into small groups with maximum six members.
2. Based on their understanding of the lecture, create a skit which shows the whole process of the central dogma.
3. The group/s that were able to clearly show the process may be given bonus points.

ENRICHMENT

1. In order to show the impact of a change in the DNA or RNA sequence, a game of breaking the code can be played.
2. Words can be generated from the one letter symbol of the different amino acids, which can be translated into base sequences or vice versa. Example, the word HAPPY, is a sequence of Histidine, Alanine, Proline and Tyrosine. You can give a sequence of base pairs which the students can decode into specific words. Also, you can change a base pair to see the change in the information.

EVALUATION (20 MINS)

The teacher can make his/her own list of questions that will allow students to practice critical thinking skills. The quiz can be administered by pairs or individually. Paired or grouped quiz allows the student to further discussed the lesson and learn from their peers. The teacher can formulate open-ended questions or multiple-choice exam from the lesson. The following are guide questions which can help the teachers in formulating their questionnaires.

1. What is the central dogma?
2. What is DNA replication? Why is it important?
3. What is Transcription? Why is it important?
4. What is Translation? Why is it important?
5. Why is the double helix structure important in the central dogma?
6. What is the difference between prokaryotic and eukaryotic protein synthesis?
7. What is the relationship among protein synthesis, DNA and diseases?
8. How is “mana” or trait inheritance in the Philippine context explained by the central dogma?
9. How can you explain the genetics of singing ability of a lot of Filipinos?
10. Genetically speaking, how can Filipinos use this information in fielding a group for FIBA or FIFA qualifiers?

REFLECTION (HOMEWORK FOR NEXT MEETING)

1. Which of the topics interest you the most? Why?
2. Which of the topics interest you the least? Why?
3. Did the activities help you understand the topic (Y/N)? Explain your answer.
4. Did you see the significance/ connection of the topic in your life?

Lesson 33: Perpetuation of Life

Content Standard

The learners demonstrate an understanding of plant and animal reproduction; how genes work; and how genetic engineering is used to produce novel products.

Performance Standard

The learners shall be able to conduct a survey of products containing substances that can trigger genetic disorders such as phenylketunaria

Learning Competency

The learners describe the process of genetic engineering

(S11/12LT-Ilej-17)**Specific Learning Outcomes**

At the end of the lesson, the learners will be able to:

1. Relate their knowledge of the central dogma on genetic engineering
2. Know the process of genetic engineering
3. Describe the definition of genetically modified organism

LESSON OUTLINE

Introduction	Communicating Learning Objectives	5
Motivation	What is your superpower?	10
Instruction	Lesson proper	30
Practice	Identify different implications of the genetic information on traits	10
Evaluation	Quiz	5
Reflection	End of the topic questions	

Materials

Table of codons, school supplies

Resources

- (1) Reece JB, Urry LA, Cain ML. 2010. Campbell Biology 10th. San Francisco(CA):Pearson Benjamin Cummings; 2010. pp. 1013-1014.
-

INTRODUCTION (5 MINS)

Communicate Learning Objectives

1. Introduce the learning objective by writing it on the board, then give the students 5 minutes to write down on a piece of paper what they already know or what they expect to learn under the specified topics:
 - Relate their knowledge of the central dogma on genetic engineering
 - Know the process of genetic engineering
 - Describe the definition of genetically modified organism

Teacher Tip:

Through this introduction, you will have an idea where to start or how you will approach your discussion. This will give you an idea where to mainly focus on the given topics to properly manage your time.

MOTIVATION (10 MINS)

1. The teacher can present a video or a picture of his or her favorite superhero. This can be a local or foreign superhero, but it is better to present to the students our local superheroes like Captain Barbel, Panday, Darna, Lastikman, etc.
2. Ask the students, if they will become a superhero with superpowers what superpowers will they have and what changes in their body will they need.

Teacher Tip:

The teacher can start the lesson by introducing an everyday tool/object he or she brought in the class and associate it to its corresponding function. This can then be related to the lesson.

INSTRUCTION (30 MINS)

Lesson Proper

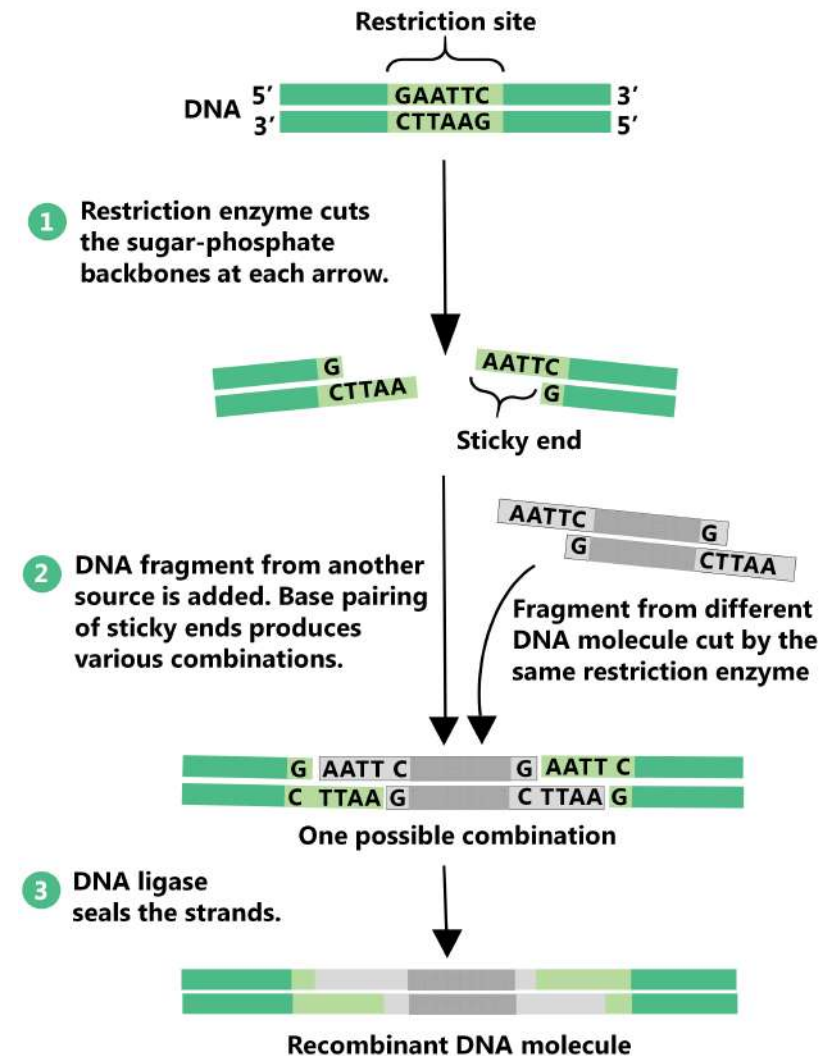
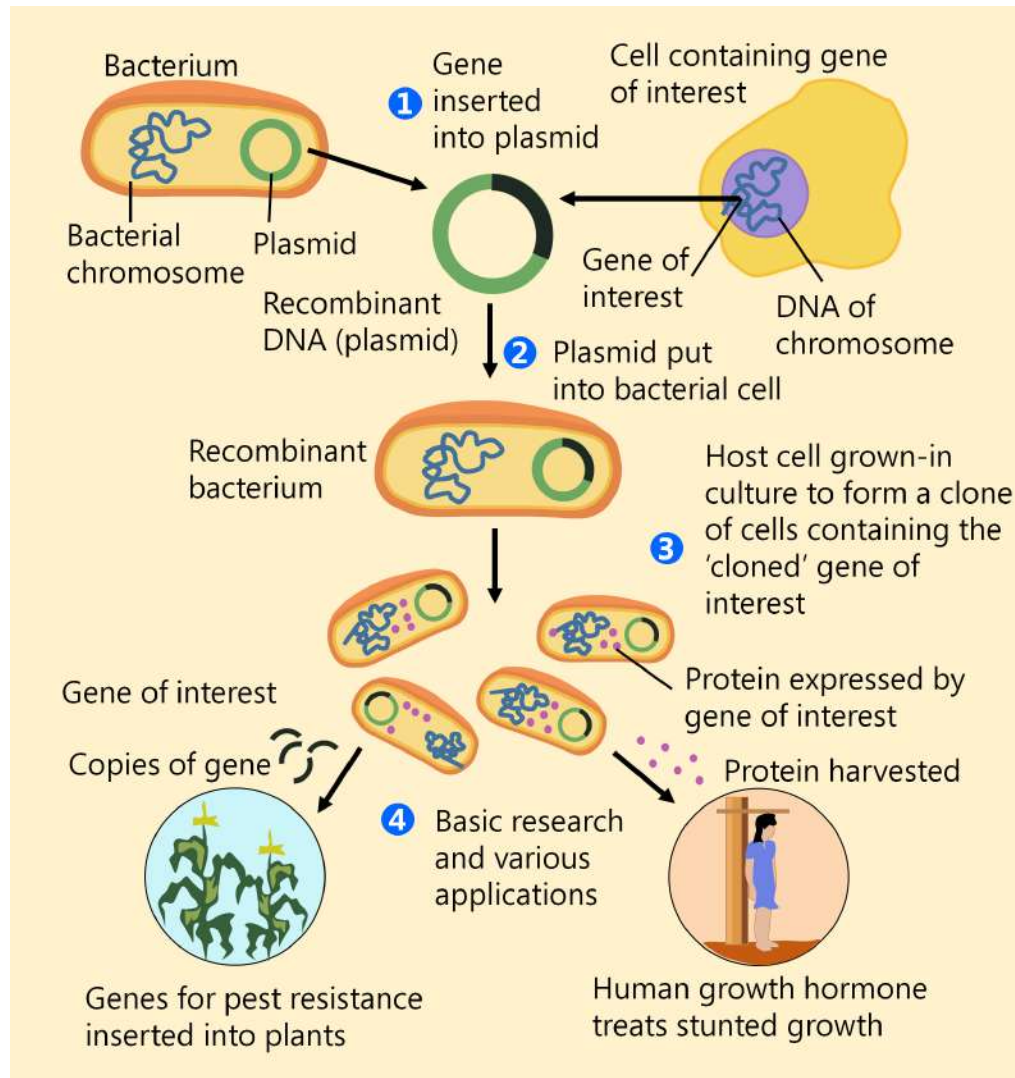
Relate the motivation with the discussion of the central dogma, where, our traits are governed by the messages we get from our DNA. Changes, from minute to large segments, can result to changes not only in a protein's ability but sometimes to a phenotype of an organism. Proceed with the Reebop activity by following the guidelines and providing the materials needed by the class. The activity can be done individually, by pair or by small group.

Teacher Tip:

The new terms in the lesson proper should be addressed first, either as an assignment for recitation or as another activity to lessen banking of terms. Even if the lesson calls for a lot of familiarization, dialogical discussion can occur if the students are equipped beforehand of the topic to be studied.

Genetic engineering is the process in which genetic material is transferred from one organism to another. Artificial selection is the most traditional form of genetic engineering, wherein specificity of synthesis of target DNA sequence is less than current genetic engineering technology. It has application on the pharmaceutical, industrial, agricultural, medical and other industries. Below is an example wherein genetic information from a firefly and a jellyfish for bioluminescence is transferred to a tobacco and a pig. This has application for medical technology, especially in tracking cell activities.

Genetic information is transferred via a vector. A vector can be a bacteria, through its circular DNA called a plasmid, or a virus. Below is a diagram of genetic transfer through the use of bacterial plasmid. A specific target genetic segment, is spliced into a bacterial plasmid and allowed to be replicated. This gene can then be transferred to a target organism, such in the case of pest-resistant crop, or proteins can be harnessed, such as in the case of insulin.



PRACTICE AND ENRICHMENT

1. Go back to the motivation activity and the Reebop activity and ask the students how will they be able to acquire their superpowers with their knowledge of genetic engineering.
2. How can the Reebop activity be related to the concept of genetic engineering?

EVALUATION (20 MINS)

The teacher can make his/her own list of questions that will allow students to practice critical thinking skills. The quiz can be administered by pairs or individually. Paired or grouped quiz allows the student to further discussed the lesson and learn from their peers. The teacher can formulate open-ended questions or multiple-choice exam from the lesson. The following are guide questions which can help the teachers in formulating their questionnaires.

1. Define genetic engineering.
2. What is a vector?
3. What are the different kinds of vector?
4. What is a plasmid? Why is it an ideal tool in replicating genetic sequences?
5. Why is bacteria a good living candidate in genetic engineering?
6. What is a recombinant DNA?
7. Why is artificial selection or selective breeding considered a form of genetic engineering?
8. What is the downside of artificial selection as a form of genetic engineering? What is its upside?
9. What is a genetically modified organism or GMO? How can it benefit mankind and the environment?
10. If you are the president of the Philippines, will you allow the open use of GMOs in the country? Why or why not?

REFLECTION (HOMEWORK FOR NEXT MEETING)

1. Which of the topics interest you the most? Why?
2. Which of the topics interest you the least? Why?
3. Did the activities help you understand the topic (Y/N)? Explain your answer.
4. Did you see the significance/ connection of the topic in your life?

Lesson 34: Perpetuation of Life

Content Standard

The learners demonstrate an understanding of plant and animal reproduction; how genes work; and how genetic engineering is used to produce novel products.

Performance Standard

The learners shall be able to conduct a survey of products containing substances that can trigger genetic disorders such as phenylketunaria

Learning Competencies

The learners conduct a survey of the current uses of genetically modified organisms and evaluate the benefits and risks of using GMOs

(S11/12LT-Ilej-18 and S11/12LT-Ilej-19)

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Relate their knowledge of the central dogma on genetic engineering
2. Know the process of genetic engineering
3. Describe the definition of genetically modified organism

LESSON OUTLINE

Introduction	Communicating Learning Objectives	5
Motivation	GMOs in the Philippines	10
Instruction	Lesson Proper	30
Practice	Debate on the advantage and disadvantage of GMOs	10
Evaluation	Quiz	5
Reflection	End of topic questions	

Materials

Table of codons, school supplies

Resources

- (1) Reece JB, Urry LA, Cain ML. 2010. Campbell Biology 10th. San Francisco(CA):Pearson Benjamin Cummings; 2010. pp. 1013-1014.
- (2) <http://www.nature.com/scitable/topicpage/genetically-modified-organisms-gmos-transgenic-crops-and-732>
- (3) <http://www.globalresearch.ca/the-battle-against-gmos-in-the-philippines-confronting-wto-towards-mainstreaming-sustainable-agriculture-in-the-country/5463069>
- (4) <http://www.philstar.com/headlines/2015/03/01/1428826/phl-now-biggest-grower-gm-crops>

INTRODUCTION (5 MINS)

Communicate Learning Objectives

1. Introduce the learning objective by writing it on the board, then give the students 5 minutes to write down on a piece of paper what they already know or what they expect to learn under the specified topics:
 - a. Know the different uses of genetically modified organisms.
 - b. Know the advantage and disadvantage of modified organisms.

Teacher Tip:

Through this introduction, you will have an idea where to start or how you will approach your discussion. This will give you an idea where to mainly focus on the given topics to properly manage your time.

MOTIVATION (10 MINS)

1. Read to the class the article in the Philippine Star, where the “Philippines is now the biggest grower of GM crops”.
2. Debate on the implication of this economically, politically, ecologically, etc.

Teacher Tip:

The teacher can start the lesson by introducing an everyday tool/object he or she brought in the class and associate it to its corresponding function. This can then be related to the lesson.

INSTRUCTION (30 MINS)

1. Report on the different uses of genetically modified organisms and group them according to pharmaceutical, industrial, agricultural and other industries.
2. Discuss the advantages and disadvantages of these GMOs.
3. In small groups, ask the class to read on the Nature article and Global Research article on GMOs. Critically compare it to the Philippine Star article and other knowledge the students have. Divide the class into two groups of pro-GMO and anti-GMO.

Teacher Tip:

The new terms in the lesson proper should be addressed first, either as an assignment for recitation or as another activity to lessen banking of terms. Even if the lesson calls for a lot of familiarization, dialogical discussion can occur if the students are equipped beforehand of the topic to be studied.

PRACTICE AND ENRICHMENT

1. Create poster or slogans on the implication/s, both positive and negative, of GMO in the Philippines.
2. Relate it to current issues on neoliberal policies, wherein the current government is party to, which can impact the farmers, not only economically but also in terms of the quality of the crops being sold.
3. Discuss the possible impact of GMOs, using the deluge of Chinese garlic in the Philippines as a case study, in writing a report as a term paper.
4. Using Heneral Luna’s line, “Bayan o Sarili/ Kalayaan o Negosyo”, how can this be related to the issue of GMOs?

EVALUATION (20 MINS)

The teacher can make his/her own list of questions that will allow students to practice critical thinking skills. The quiz can be administered by pairs or individually. Paired or grouped quiz allows the student to further discussed the lesson and learn from their peers. The teacher can formulate open-ended questions or multiple-choice exam from the lesson. The following are guide questions which can help the teachers in formulating their questionnaires.

1. What are the positive impacts of GMOs?
2. What are the negative impacts of GMOs?
3. What are the industries use GMOs?
4. Is there a biological reason in resisting the use of GMO?
5. What are possible reasons not to allow GMOs in a country?
6. As a country with a history of economic, political, psychological dependence and subservience to other countries, do you think the use of GMO will be more beneficial or detrimental?
7. Barring biological use of GMOs, how is the use of GMO in the country a symptom of political and economic dependency to other countries?
8. How can the benefits of GMOs outweigh its negative effects?

REFLECTION (HOMEWORK FOR NEXT MEETING)

1. Which of the topics interest you the most? Why?
2. Which of the topics interest you the least? Why?
3. Did the activities help you understand the topic (Y/N)? Explain your answer.
4. Did you see the significance/ connection of the topic in your life?

Lesson 35: How Animals Survive (Nutrition)

Content Standard

The learners demonstrate an understanding of nutrition, specifically as to how food get into cells.

Performance Standard

The learners shall be able to make a presentation of some diseases that are associated with the various organ systems

Learning Competencies

The learners explain the different metabolic processes involved in the various organ systems and describe the general and unique characteristics of the different organ systems in representative animals (**S11/12LT-IIIaj-20 and S11/12LT-IIIaj-21**)

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Know the structure function relationship in the various organ systems
2. Able to synthesize the various functions of the organ systems in the day-to-day activity of an individual
3. Used their knowledge of physiological processes to understand the different diseases associated with the organ systems

LESSON OUTLINE

Introduction	Communicating Learning Objectives	5
Motivation	Philippine Native Food	10
Instruction	Lesson Proper	40
Practice	Debate	20
Evaluation	Quiz	15
Reflection	End of topic questions	

Materials

Table of codons, school supplies

Resources

- (1) Reece JB, Urry LA, Cain ML. 2010. Campbell Biology 10th. San Francisco(CA):Pearson Benjamin
- (2) <http://classes.midlandstech.edu/carterp/courses/bio225/chap16/Slide10.jpg>

INTRODUCTION (5 MINS)

Communicate Learning Objectives

1. Introduce the learning objective by writing it on the board, then give the students 5 minutes to write down on a piece of paper what they already know or what they expect to learn under the specified topics:
 - a. Know the structure function relationship in the various organ systems
 - b. Able to synthesize the various functions of the organ systems in the day-to-day activity of an individual
 - c. Used their knowledge of physiological processes to understand the different diseases associated with the organ systems

Teacher Tip:

Through this introduction, you will have an idea where to start or how you will approach your discussion. This will give you an idea where to mainly focus on the given topics to properly manage your time.

MOTIVATION (10 MINS)

To start the class, ask the student to share the Philippine native food that they have brought in class. Ask anyone the ingredients of the food they have tasted or brought, if they do not know all the ingredients just ask them to give the main ingredient of the food. Help the student/s in classifying if the food is mostly or high in carbohydrates, proteins, fats or nucleic acids. You may write the classification using a table, diagrams or any visual aid which can later be used in summing up the lesson.

Teacher Tip:

The teacher can start the lesson by introducing an everyday tool/object he or she brought in the class and associate it to its corresponding function. This can then be related to the lesson.

INSTRUCTION (40 MINS)

Animal nutrition is the process of taking in, taking apart and taking up the nutrients from a food source. Food processing has four main stages: Ingestion, Digestion, Absorption and Elimination or Egestion.

In ingestion, or process of taking in food substances, the animal takes in food in different ways. Microscopic animals, for instance, can use special cavities which can allow entrance of food or they can use phagocytosis or pinocytosis wherein food particles are engulfed, thus, creating a food vacuole.

The new terms in the lesson proper should be addressed first, either as an assignment for recitation or as another activity to lessen banking of terms. Even if the lesson calls for a lot of familiarization, dialogical discussion can occur if the students are equipped beforehand of the topic to be studied.

The teacher should be able to define the different mechanisms in the processing of food as digestion is only a part of the whole process.

The importance of mechanical digestion should be highlighted as this has an implication in acquisition of energy from our food. The easier to chemically digest food, the easier to obtain energy from it.

The different functions of the specialized compartments of the digestive tract should be highlighted to prevent some misconceptions. Such as the function of the stomach is not only for digestion but also for storage of food. Chemical digestion mainly happens in the small intestine, but it also occurs in the mouth and the stomach. The different functions of the accessory glands should be discussed as they greatly aid in the digestion of substances.

In other animals, such as in cnidarians (jellyfish, anemone, coral) where the entrance and exit of food and waste is the same, the region where this occurs is called the gastrovascular cavity. Gastro for digestion, vascular for circulation of movement of digested food. Below, the illustration shows how food is processed in animals with gastrovascular cavities.

In other animals, with complete digestive system, where entrance and exit of food and wastes are different, there are different mechanisms of ingestion depending on their evolutionary adaptation to their food. The four main feeding mechanisms are filter feeding, substrate feeding, fluid feeding and bulk feeding.

1. **Filter feeding**- uses adaptation in feeding food particles from the environment, which is usually aquatic. Examples of these are clams, mussels, whales, etc.
2. **Substrate feeding**- animals live in or on their food source. Examples of this are the leaf miner, maggots and other parasites.
3. **Fluid feeding**- animals suck nutrient-rich fluid from a host or a source. They have different adaptations in order to get food such as the proboscis of mosquitoes, the long tongue of nectar-feeding bats and long beaks of hummingbirds.
4. **Bulk feeding**- animals, such as us humans, take in large particle sized food. Different animals have acquired different adaptations such as tentacles, claws, venomous fangs, large mandible and teeth which aids in killing prey or tearing off pieces of meat or vegetation

Digestion of food involves either intracellular digestion or extracellular digestion or both processes. Univellular organisms and members of the Phylum Porifera use intracellular digestion in breaking down food. It involves endocytosis (phagocytosis/pinocytosis) of basic food molecules which can easily be broken down through chemical hydrolysis. More complex molecules are harder to ingest as it might be bigger than the cells are able to ingest. In other animals, such as the cnidarians, food is first digested extracellularly then endocytosed and intracellularly digested. We can say that, cnidarians bridge the evolution from intracellular digestion to complete extracellular digestion by exhibiting both processes. For animals with complete digested system, where specialization of organs is possible, extracellular digestion of food is possible. Chemical hydrolysis occurs within the lumen or the space of the digestive system with the aid of various chemicals, enzymes and hormones. Enzymes are molecules which speed up a reaction, in the case of digestion it helps in the chemical hydrolysis of the different biomolecules. Digestion can either be mechanical or chemical. Mechanical digestion aids in physically breaking down food particles for easier chemical digestion. Chemical digestion is the process of breaking down complex molecules into simpler molecules through chemical hydrolysis.

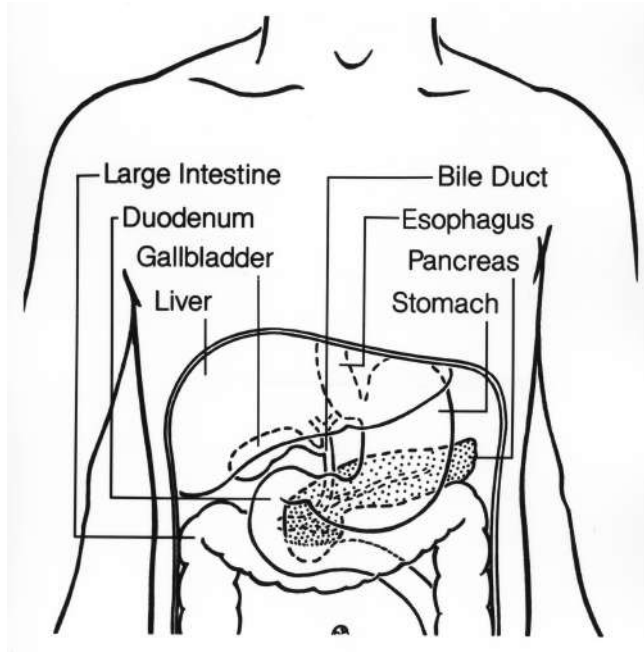
Absorption allows the animals to acquire the necessary energy, organic molecules and essential nutrients from the digested food. Chemical energy comes from the break down of ATP which comes from sources such as sugars from carbohydrates. Organic molecules can serve as the organic building block of the body where muscles, connective tissues, nerve tissues are built. These organic molecules are the biomolecules that we acquire from food: carbohydrate, protein, fats and nucleic acids. Carbohydrates are important for instant energy, but if not used will be stored and can turn into fats. Proteins, which are made up of amino acids, are the building blocks of different structures in the organism, e.g. muscles, cells, antibodies, etc. Fats are great source of energy as they can store a lot of energy. Nucleic acids are important for building blocks of genetic information. Essential nutrients are substances which the animal's own body cannot synthesize, thus, comes from the food source. Essential amino acids, essential fatty acids, vitamins and minerals are examples of essential nutrients.

As food is only partially digested, not all particles are absorbed by the body. The semi-digested food, which in turn becomes waste is then eliminated or digested. In some animals, such as humans, water is first reabsorbed before it is eliminated or egested out of the body. Different symbiotic relationships are present in order to fully utilized the substances present in waste (feces) before it is finally released. Bacteria which can synthesized Vitamin K is present in human gut, some bacteria process the feces and creates by-product rich in methane or hydrogen sulfide which results in flatus (fart) which smell like rotten egg.

THE HUMAN DIGESTIVE SYSTEM

The human digestive system can serve as a model for other organisms with complete digestive system. Variations is a result of adaptation to particular food, such as the four-chambered stomach of the cow, the long cecum (appendix) of herbivores, rough tongue and sharp dentition of carnivores, etc.

The illustration below shows the digestive system in humans, to the right is an idealized schematic diagram of the human digestive system.



Source:

[https://upload.wikimedia.org/wikipedia/commons/c/c9/Digestive_tract_\(upper\).jpg](https://upload.wikimedia.org/wikipedia/commons/c/c9/Digestive_tract_(upper).jpg)

The mouth or oral cavity- is responsible for ingestion. In humans, the mouth have specialized dentition for mechanical digestion of food. Also, chemical digestion of food occurs in the mouth, specifically, of carbohydrates. With the aid of the salivary gland, food is softened and rolled by the tongue, which results in a round, semi-digested food called the bolus. Some animals do not have teeth, such as birds and earthworms, they use a structure called gizzard, a muscular organ which grinds food with the aid of ingested pebbles or stones.

The bolus enters the digestive tract, via a cross-road of food and air called the pharynx. To prevent food from entering the respiratory system, the epiglottis covers the opening (called the glottis) to the respiratory when swallowing.

The esophagus, which has voluntary muscles at the pharyngeal end, allows the movement of bolus to the stomach by lubricating its walls with mucus produced by goblet cells. Movement of food, not only through the esophagus, but throughout the digestive tract is caused by peristalsis or the wavelike movement of the muscles of the organs of digestion. Mucus not only allows easier movement of food, but it also protects the lining of esophagus from acids of the stomach.

The stomach is a bag which mainly functions in the storage of food. Chemical digestion of food starts here through the action of pepsin (an enzyme for protein digestion) and hydrochloric acid (HCl) helps in breaking cells, activating pepsinogen to pepsin, and denaturing proteins. Denaturation is the process of breaking the bonds of protein, through acids, bases, heavy metals, high temperature and others. This is observed in cooked white egg, whitening of the lips when consuming acidic food, etc. The product of digestion in stomach is called the chyme. The stomach has two valves at each end, which regulates the entrance and exit of food. Cows do not have four stomachs, rather they have four-chambered stomach which aids in chemical digestion of cellulose in plants. As cows do not have the ability to completely digest cellulose, they have mutualistic relationship with bacteria which digests cellulose, needing the four-chambers of the stomach.

When the stomach is filled, the product of its digestion called chyme or acidic chyme (due to its acidic nature) moves to the small intestines. In the small intestines, chemical digestion of the four biomolecules occur. Different enzymes and hormones are activated/released to the small intestine by the small intestine itself, the liver and the pancreas. These hormones, chemicals and enzymes are responsible in turning complex biomolecules into simpler molecules. Bile for example, is a substance produced by the liver and stored by the gall bladder which aids in the digestion of fats by emulsification of fat molecules. Villus (plural- villi) and microvillus (plural- microvilli) are structures responsible for the efficient absorption of the digested molecules. Thus, the small intestine has the largest surface area among the organs in the digestive system.

The large intestine, termed for its larger diameter compared to the small intestine, is responsible for water reabsorption and temporary storage of feces. Water from the process of digestion, which comes from the surrounding tissues (mucus, saliva, chemicals), is recycled by the large intestine by reabsorbing it. The rate of water reabsorption has implication on the hardness/softness of the feces to be eliminated. In humans, the cecum is a structure called appendix, a vestigial organ. It does not have any known digestive function, but some argue that it has immune functions. For herbivores, the cecum is a very long structure as they house organisms which can aid in the digestion of cellulose just like in the four-chambered stomach of cows. The rectum is the structure of the large intestine which temporary store feces, the movement of the feces is regulated by a voluntary muscle called the anus.

PRACTICE AND ENRICHMENT

Using the table of the native Filipino food, ask the student where are the sites of digestion of the food. Using their knowledge of mechanical and chemical digestion, they should be able to identify site of digestion of the given food. During times, when the you or the students eat vegetables, why are there some complete pieces or fragments of the vegetables found with the feces? Why aren't there meat or other tough food substance with it?

EVALUATION (20 MINS)

The teacher can make his/her own list of questions that will allow students to practice critical thinking skills. The quiz can be administered by pairs or individually. Paired or grouped quiz allows the student to further discussed the lesson and learn from their peers. The teacher can formulate open-ended questions or multiple-choice exam from the lesson. The following are guide questions which can help the teachers in formulating their questionnaires.

1. What are the different processes involved in the processing of food?
2. What is the difference between intracellular and extracellular digestion? Give representative organisms.
3. What is the difference between mechanical and chemical digestion? What is the importance of mechanical digestion?
4. Give the different structures responsible for mechanical digestion and their representative organism.
5. Relate the ability of the stomach to inflate and deflate to its function, to store food.
6. What is an enzyme? What is its function in digestion?
7. Why is there a need for different digestive enzymes?
8. What is peristalsis? How does it allow movement of substances along the digestive tract even in organisms in space?
9. How does your knowledge of the nutrition determine your diet? Explain.
10. What are essential nutrients? How does a vegetarian diet impact your ability to acquire essential nutrients?

REFLECTION (HOMEWORK FOR NEXT MEETING)

- Which of the topics interest you the most? Why?
- Which of the topics interest you the least? Why?
- Did the activities help you understand the topic (Y/N)? Explain your answer.
- Did you see the significance/ connection of the topic in your life?

Lesson 36: How Animals Survive (Circulation and Gas Exchange)

Content Standard

The learners demonstrate an understanding of circulation in the internal transport system, and gas exchange with the environment.

Performance Standard

The learners shall be able to make a presentation of some diseases that are associated with the various organ systems.

Learning Competencies

The learners explain the different metabolic processes involved in the various organ systems, and describe the general and unique characteristics of the different organ systems in representative animals (**S11/12LT-IIIaj-20 and S11/12LT-IIIaj-21**)

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Know the structure function relationship in the various organ systems
2. Able to synthesize the various functions of the organ systems in the day-to-day activity of an individual
3. Used their knowledge of physiological processes to understand the different diseases associated with the organ systems

LESSON OUTLINE

Introduction	Communicating Learning Objectives	5
Motivation	Patintero or Agawan Panyo	10
Instruction	Lesson Proper	40
Practice	Debate on the advantage and disadvantage of GMOs	20
Evaluation	Quiz	15
Reflection	End of the Topic Questions	

Materials

Table of codons, school supplies

Resources

- (1) Reece JB, Urry LA, Cain ML. 2010. Campbell Biology 10th. San Francisco(CA):Pearson Benjamin
- (2) <http://classes.midlandstech.edu/carterp/courses/bio225/chap16/Slide10.jpg>

INTRODUCTION (5 MINS)

Communicate Learning Objectives (Nutrition)

1. Introduce the learning objective by writing it on the board, then give the students 5 minutes to write down on a piece of paper what they already know or what they expect to learn under the specified topics:
 - a. Know the structure function relationship in the various organ systems
 - b. Able to synthesize the various functions of the organ systems in the day-to-day activity of an individual
 - c. Used their knowledge of physiological processes to understand the different diseases associated with the organ systems

Teacher Tip:

Through this introduction, you will have an idea where to start or how you will approach your discussion. This will give you an idea where to mainly focus on the given topics to properly manage your time.

MOTIVATION (10 MINS)

Through the game of “mataya taya” or “it”, patintero or agawan panyo the teacher can start the lesson. These activities will aid in increasing the metabolic rate, thus, has implication on the student’s circulation and respiration. After the game, ask the student how they feel and what they can observe in terms of their heart rate, respiratory rate, pulse rate, perspiration, etc.

Teacher Tip:

The teacher can start the lesson by introducing an everyday tool/object he or she brought in the class and associate it to its corresponding function. This can then be related to the lesson.

INSTRUCTION (40 MINS)

Lesson Proper

The products of digestion is important for the energy that an animal utilized for its day-to-day activity. This is aided by the circulatory system, for transport of the products of digestion throughout the body of the animal, while the respiratory system is responsible for the conversion of the product of digestion into usable energy.

Teacher Tips:

The new terms in the lesson proper should be addressed first, either as an assignment for recitation or as another activity to lessen banking of terms. Even if the lesson calls for a lot of familiarization, dialogical discussion can occur if the students are equipped beforehand of the topic to be studied.

The Circulatory System

There are different ways in which animals transport substances across their body. Animals with thin body rely on diffusion, which is the movement of substances from high concentration to low concentration, in the transport of substances. Together with a fluid medium, a thin structure allows diffusion to occur efficiently. Thus, organisms such as those with gastrovascular cavity like cnidarians, flatworms use diffusion in moving substances across and within their bodies.

The importance of diffusion in exchange of substances should properly be discussed. This will serve as a foundation on the discussion on the need for circulatory system.

Compared to cnidarians, the gastrovascular cavity of flatworms have extensions in order to reach areas of the body far from the axis. Without these extensions of the gastrovascular cavity, diffusion might not be enough in the transport of substances.

To overcome the problems with diffusion, animals with thicker tissues have devised a way in order to transport substances across and within their bodies. Animals have evolved structures which carry substances (circulatory fluid, e.g. blood), pipes (blood and lymph vessels) and a pumping organ (heart). Animals with these structures either have an open or closed circulatory system. In an open circulatory system, blood is not fully enclosed in a vessel and is pumped out of the system via an exit called an ostium to a space which surrounds tissues called a sinus. When the heart contracts, the circulatory fluid goes out of the system, if the heart relaxes the fluid returns. As the blood goes directly to the tissues, it mixes with the interstitial fluid which surrounds tissue and cells and is called a hemolymph. The interstitial fluid allows diffusion from the blood to a cell. In an open circulatory system, circulatory and respiratory systems are independent of each other.

In animals with closed circulatory system, the circulatory fluid does not go out of the vessel. Exchange occurs through diffusion via thinner vessels called capillaries across the interstitial fluid. For both types of circulatory systems, the pumping organ (heart) allows substances to travel long distances with the aid of the vessels, which acts like a highway for transport. With the ability of the circulatory fluid to carry a lot of substances, it allows efficient bulk transport of substances. Diffusion is still used, but only in exchange of substances not in its bulk transport.

THE CLOSED CIRCULATORY SYSTEM

The thicker body conformation of animals, necessitate to counter the problem of transporting substances across distances. Not only diffusion, but also pressure and friction play a role in diminishing the efficiency of bulk transport in animals. Different animals, have adapted different mechanisms in transport such as in fishes where a single circulation is enough. Single circulation has implication on pressure created in pushing circulatory fluid, as it may lose the pressure to return to the heart. Once the circulatory fluid has passed through the capillaries, in order for diffusion to be efficient, speed of movement of the circulatory should decrease. As a result, the pressure decreases which might not be enough to push the blood back to the heart. But fishes have evolved an adaptation wherein their blood vessels are found between muscles, which squeezes the blood back to heart everytime the muscle contracts, whenever they are swimming. For those

Teacher Tip:

Pressure formation, created by a heart, clarifies the importance of the heart.

The respiratory system, not only delivers oxygen and waste gases but more importantly delivers oxygen for energy production.

organisms which might have thicker bodies, thus, needing more pressure in pushing their circulatory fluid have adapted a double circulation. In double circulation, blood does not move in a single direction, as it goes back to the heart to restore pressure. Below is an illustration showing the different circulation.

Amphibian double circulation differs from mammalian, crocodilian and avian as blood is mixed. The presence of one ventricle does not prevent the mixing of blood, unlike in the four-chambered heart of a mammal, crocodilian and an avian where the ventricle is divided into two. Mixing of blood does not have major implication on amphibians as 1) they have low metabolic rate, thus, less need for energy; 2) they have the ability to respire through their skin, thus not needing to fully oxygenate the blood through the lungs.

STRUCTURES

1. Atrium- receives blood
2. Ventricle- pumps blood
3. Artery- transports blood away from the heart, muscular
4. Vein- transports blood back to the heart, has valves and thinner in structure
5. Capillary- exchange of substances, has very thin walls
6. Venule- small vein
7. Arteriole- small artery
 - a. The pulse is the wavelike force which is a result of the pumping of blood through an artery with decreasing diameter. As the diameter of the artery decreases, the walls of the artery stretch to accommodate the blood that is passing through it.
 - b. The heart has the ability to produce its own electrical signal to stimulate the contraction of the heart muscles. Thus, the heart is independent from the brain, the brain only affects the rate of heart contraction but not starts the contraction of the heart. The cardiac cycle is the complete cycle of contraction and relaxation, together with the intervening phase.
 - c. Systole- is the contraction phase of the cardiac cycle
 - d. Diastole – is the relaxation phase of the cardiac cycle

GAS EXCHANGE

Gas exchange is very important animals, as they require oxygen in the production of higher amount of energy compared to process of energy production without oxygen. Aerobic respiration is the term used when oxygen is present in the production of energy, while anaerobic respiration is the process energy production without oxygen. In order to acquire oxygen, different animals have evolved different adaptations in order to adapt to their environment. What is constant among these organisms are 1.) a thin respiratory structure, 2.) moist respiratory surface and 3.) respiratory structure with high surface area.

As the organisms above live in an aquatic environment, they do not have a problem with keeping their respiratory surface moist. But they face a different problem, as water is heavier and has less O₂ concentration than same volume of air. Thus, organisms need to ventilate their respiratory surfaces by increasing the contact between their respiratory surface and the respiratory medium. There are different ways to ventilate the respiratory medium, one method is the countercurrent exchange mechanism used by fish. Through the counter current exchange mechanism, the blood or the circulatory medium will always have a less concentration of oxygen compared to the respiratory medium. Thus, oxygen will always move from the water to the blood and waste gases will always move from the blood to the respiratory medium.

AIR AS A RESPIRATORY MEDIUM

As air is lighter and has more oxygen content compared to the same volume of water, ventilation is not much of a problem of terrestrial organisms. The problem with air as a respiratory medium is its dehydrating characteristic, thus, terrestrial organisms keep their respiratory surfaces moist by keeping it within their body. This has implication in the surface area of the respiratory structure, again, organisms were able to evolved adaptation to counter this problem.

THE TRACHEAL SYSTEM OF INSECTS

The tracheal system of insects has a branched network of tracheal tube which responds to the problem of decreased surface area in the respiratory structure. The tracheal system opens externally through the side of the insect through a structure called a spiracle. Air enters and exit through the spiracles. As the respiratory system of insects are independent from their circulatory system, gases is directly exchanged through tracheoles which have extensions that are directly connected to the cells. Air sacs act like aspirator which takes in and push out air out of the body of the insects.

THE MAMMALIAN RESPIRATORY SYSTEM

Compared to insects, mammals and other organisms have respiratory system that work together with their circulatory system. Gases are transported via the bloodstream and are exchanged via diffusion. Some organisms which have smaller lung capacity compensate gas exchange through thin epithelial lining of their anus or mouth like in turtles or through the skin like in frogs.

Gas exchange occurs via the movement of air from the external environment and is exchanged via a dead-end of clusters of thin epithelium of the walls of air sacs called alveoli. Compared to mammalian lungs, bird lungs do not have a problem with air not exhaled, as there is a unidirectional movement of the respiratory medium. This is possible because the lungs of birds do not terminate to a dead-end, rather there is a complete circuit of flow of air which pushes air complete out of the respiratory system.

TERRESTRIAL VENTILATION

Ventilation in lungs is called breathing, the alternating process of inhalation and exhalation. There are two mechanisms of breathing, one is positive breathing and the other is negative breathing. In positive breathing air is pushed into the lungs, such as in frogs. Meanwhile, humans and other mammals use negative pressure breathing by sucking in air in to the lungs through the creation of a negative pressure. When chest muscles contract, they increase the volume of the chest cavity decreasing the pressure inside. As the pressure decreases inside the lungs, air is pulled into the lung cavity. The relaxation of the chest muscles squeezes out air through the process called exhalation.

GAS EXCHANGE AND THE CIRCULATORY SYSTEM

As the circulatory system functions in the delivery of the energy sources in the form of molecules processed by the digestive system, the respiratory system is important in the released of waste gases (CO₂) and the delivery of oxygen for energy production. Sugars are broken down, and the resulting process results in the formation of ATP, which when broken down by cells produce energy which the cells can use for its metabolic activities. The process of glycolysis, is an anaerobic process which does not require oxygen but creates little amount of ATP. The electron transport chain (ETC), which uses oxygen produces the most ATP. Along the process, CO₂ is produced as a by-product, which the circulatory system and respiratory system released via exhalation. Below is an summary of the whole process of cellular respiration, together with the ATP produced per mechanism.

PRACTICE AND ENRICHMENT

Play the game again, which was played before the lesson. But compared before, ask the students to records their initial heart rate, breathing rate and pulse rate. Start the game again, at the end of the game ask the students to record the final respiratory, heart and pulse rate. Ask them of a generalization then can make based on the activity on the relationship of the respiratory system and the circulatory system.

EVALUATION (20 MINS)

The teacher can make his/her own list of questions that will allow students to practice critical thinking skills. The quiz can be administered by pairs or individually. Paired or grouped quiz allows the student to further discussed the lesson and learn from their peers. The teacher can formulate open-ended questions or multiple-choice exam from the lesson. The following are guide questions which can help the teachers in formulating their questionnaires.

1. What are the different types of circulatory system?
2. What is the role of diffusion in organisms with thin body structure and thick body structure? How are substances transported in both organisms?
3. How does the circulatory system overcome the problem of diffusion in the transport of substances in organisms?
4. What is the difference between an open and closed circulatory system? Explain.
5. Why is there a need to have a double type of circulation? Explain.
6. Why is the respiratory system of arthropods separate from their circulatory system? Explain.
7. How do animals in aquatic environment adapt on the low concentration of oxygen in their environment? Explain.
8. What is the difference between positive pressure breathing and negative pressure breathing? Explain.
9. Sketch the flow of gases along the respiratory system.
10. How does the respiratory system of birds allow them to fly? Explain.

REFLECTION (HOMEWORK FOR NEXT MEETING)

1. Which of the topics interest you the most? Why?
2. Which of the topics interest you the least? Why?
3. Did the activities help you understand the topic (Y/N)? Explain your answer.
4. Did you see the significance/ connection of the topic in your life?

Lesson 37: How Animals Survive (Homeostasis and Waste Removal)

Content Standard

The learners demonstrate an understanding on the need for homeostasis.

Performance Standard

The learners shall be able to make a presentation of some diseases that are associated with the various organ systems.

Learning Competencies

The learners explain the different metabolic processes involved in the various organ systems and describe the general and unique characteristics of the different organ systems in representative animals (**S11/12LT-IIIaj-20 and S11/12LT-IIIaj-21**)

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Know the structure function relationship in the various organ systems
2. Able to synthesize the various functions of the organ systems in the day-to-day activity of an individual
3. Used their knowledge of physiological processes to understand the different diseases associated with the organ systems

LESSON OUTLINE

Introduction	Communicating Learning Objectives	5
Motivation	Wormy Worms	10
Instruction	Lesson Proper	40
Practice	Debate on the advantage and disadvantage of GMOs	20
Evaluation	Quiz	15
Reflection	End of the Topic Questions	

Materials

Table of codons, school supplies

Resources

1. Reece JB, Urry LA, Cain ML. 2010. Campbell Biology 10th. San Francisco(CA):Pearson Benjamin
2. <http://classes.midlandstech.edu/carterp/courses/bio225/chap16/Slide10.jpg>

INTRODUCTION (5 MINS)

Communicate Learning Objectives (Nutrition)

1. Introduce the learning objective by writing it on the board, then give the students 5 minutes to write down on a piece of paper what they already know or what they expect to learn under the specified topics:
 - a. Know the structure function relationship in the various organ systems
 - b. Able to synthesize the various functions of the organ systems in the day-to-day activity of an individual
 - c. Used their knowledge of physiological processes to understand the different diseases associated with the organ systems

Teacher Tip:

Through this introduction, you will have an idea where to start or how you will approach your discussion. This will give you an idea where to mainly focus on the given topics to properly manage your time.

MOTIVATION (10 MINS)

Form the class into groups with maximum of five members. Assign them to bring bottles, salt, distilled water, tap water. Dilute salt in tap water of different concentrations, you can be very specific with your concentration, or you can measure salt using one spoon. Place one worm per bottle, after sometime compare the size of the worm to each other. Ask the group to make a generalization based on the amount of water the worm has released or taken in.

Teacher Tip:

The teacher can start the lesson by introducing an everyday tool/object he or she brought in the class and associate it to its corresponding function. This can then be related to the lesson.

INSTRUCTION (40 MINS)

The activity tries to show the movement of water in and out of a body of an organism. Different organisms balance substances in relation to their internal and external environment through the process of homeostasis. Homeostasis involve balancing of the internal concentration of an organism compared to external environment. Also, heat is also balanced in relation to the environment of an organism. The integumentary system and the excretory system play a major role in homeostasis. The circulatory and respiratory system also helps in homeostasis.

Teacher Tip:

The new terms in the lesson proper should be addressed first, either as an assignment for recitation or as another activity to lessen banking of terms. Even if the lesson calls for a lot of familiarization, dialogical discussion can occur if the students are equipped beforehand of the topic to be studied.

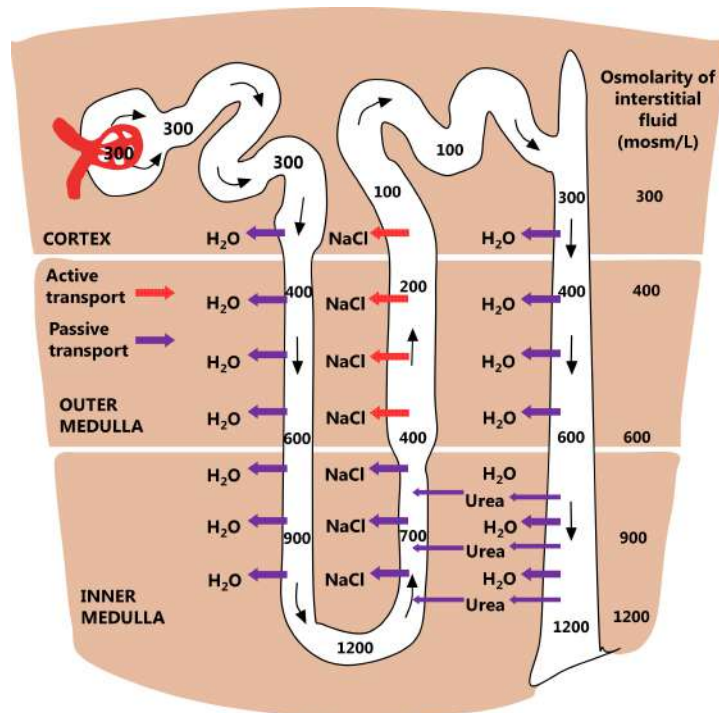
Conformers vs Regulators

Animals which copy the environmental factors are said to be conformers, there are osmoconformers (concentration conformers) and thermoconformers (temperature conformers). Animals which maintain their body's internal factors compared to the environment are said to be regulators, there are osmoregulators (concentration regulators) and thermoregulators (temperature regulators). Marine invertebrates are example of osmoconformers, while marine vertebrates are example of osmoregulators. Ectotherms or

“cold-blooded” animals are thermoconformers, they rely on their external environment for their body’s internal temperature. The term cold-blooded is a misnomer, as ectotherms sometimes have higher body temperature compared to “warm-blooded” organisms as they copy their environment’s temperature. Endotherms or thermoregulators maintain their body’s internal temperature through metabolism, as a result they have higher metabolism than thermoconformers. There are different ways in which organisms have adapted to their environment in terms of homeostasis, such as behavioral, physiological, migration and structural adaptations.

The bird “tarat” or brown shrike, exhibits migratory response to changing environment by travelling long distances depending on the climate. Their migration coincides also with their reproductive timetable.

Physiological and structural adaptation is observed in the placement of blood vessels for heat retention, while structures of for osmoregulation such as in the kidneys are also placed adjacent to each other like the process of countercurrent exchange mechanism. The illustration below, shows this process



Teacher Tip:

Through this introduction, you will have an idea where to start or how you will approach your discussion. This will give you an idea where to mainly focus on the given topics to properly managed your time.

Teacher Tip:

The teacher can start the lesson by introducing an everyday tool/object he or she brought in the class and associate it to its corresponding function. This can then be related to the lesson.

Teacher Tip:

The new terms in the lesson proper should be addressed first, either as an assignment for recitation or as another activity to lessen banking of terms. Even if the lesson calls for a lot of familiarization, dialogical discussion can occur if the students are equipped beforehand of the topic to be studied.

Also, the nervous system plays a role in homeostasis where negative feedback mechanism and positive mechanism are present. Negative feedback mechanisms regulate reactions while positive feedback ensures the continuance of the reaction.

Perspiration, is a mechanism which shows homeostatic reaction wherein temperature and/or concentration is controlled. Water is a good cooling agent as it is able to absorb high heat and also dilutes solutes.

THE EXCRETORY SYSTEM

In order to remove wastes, animals have the excretory system, which enables it to remove excess salt or water in the body. If there is excess water, waste material is diluted but if there is low water, waste might be concentrated or none at all. Organisms have different wastes in the form of nitrogenous wastes which they need to excrete.

The type of nitrogenous wastes vary in toxicity, energy required for excretion and solubility. Ammonia, which is the most toxic is the most soluble to water and the least energy expensive among the nitrogenous wastes. This type of waste is characteristic of animals which live in aquatic environment as they are able to easily dilute it, thus its toxicity is neutralized.

Meanwhile, uric acid is the least soluble and most expensive but is able to recycle the most water. It is characteristics of animals living in an environment low in water. Urea's toxicity, energy requirement and solubility is in between the two nitrogenous wastes. Humans and other mammals use it, meanwhile, sharks retain a lot of urea to allow it to be more or less buoyant compared to the water. It protects itself from accumulation of toxicity by having a chemical that protects its cells called, trimethylamine oxide or TMAO which protects the proteins of the cells.

Waste removal follows the following processes, 1.) filtration, 2.) reabsorption, 3.) secretion, and 4.) excretion

Different organisms have different excretory system, such as the protonephridia of flatworms, metanephridia of annelids, Malpighian tubules of insects and the nephrons of humans and mammals.

Overview of excretion in mammals

Materials from the blood are transferred to the nephrons where filtration, reabsorption and secretion will occur. Excretion will occur at the urethra. **Remember:** substances do not move back to the lumen of the tubule from the interstitial fluid because of small surface area in the exterior side compared to interior (lumen part)

1. Filtrate is produced when substances from the blood is filtered in the glomerulus and the Bowman's capsule. The concentration of this filtrate is the same compared to the concentration of the interstitial fluid in other parts of the body.
2. The filtrate will move towards the proximal tubule. Volume and composition of the filtrate is changed here. Production of H^+ ions and NH_3 to balance the pH of the filtrate (produced by the transport epithelium). Drugs and poison are transferred from the peritubular capillaries to the proximal tubule.

Remember: the P. tubule reabsorbs NaCl and H_2O . The transport epithelium in p tubule transport Na^+ (active) and Cl^- (passive) into the interstitial fluid. Water follows via osmosis.

Important: transferred back to the capillaries: NaCl, Nutrients (active); HCO_3^- , H_2O , K^+ (passively)

Secreted into the p. tubule: H^+ (active); NH_3 (passive)

3. Water is reabsorbed greatly in the descending part of the loop of Henle. The transport epithelium that lines the tubule is greatly permeable to water but not to salt.
4. The thin ascending loop of Henle moves salt from the filtrate passively. The thick ascending loop of Henle moves NaCl actively.

Important: animals with very long loop of Henle or with juxtamedullary nephrons conserve water efficiently because of the mechanisms mentioned in 3 and 4. The mechanism involve is the countercurrent exchange of substances. At upper part of the loop of Henle concentration of solute is not as high as you descend down the loop. Water is reabsorbed by the interstitial fluid all the way down because of varying change in osmolarity of the interstitial fluid. The interstitial fluid becomes more hypersomotic compared to the filtrate as you descend because the ascending loop of Henle transports the NaCl in the filtrate.

5. The distal tubule acts on the secretion and reabsorption of substances just like the p tubule. It also controls the pH of the filtrate by secretion of H^+ and reabsorption of HCO_3^-

Important: reabsorbed: NaCl, HCO_3^- (active); H_2O (passive)

Secreted: K^+ and H^+ (active)

6. The collecting duct determines how much salt is excreted in the urine. It is permeable to water but not to salts.

Important: reabsorbed: H_2O , urea (due to high concentration in the urine) (passive) NaCl (active)

Conservation of water

1. Here filtrate concentration is always compared to normal concentration of interstitial fluid.
 - a. In the Bowman's capsule: same concentration because only filtration of small substances occurred. (About 300 mosm/L)
 - b. In the descending loop of Henle: increases from 300 to 1200 at the bottom part of the loop (water is greatly reabsorbed)
 - c. In the ascending limb: filtrate concentration decreases

Importance: Loss of water in the ascending limb produces a hyperosmotic filtrate. This hyperosmotic filtrate will produce the gradient that will move the salt from the filtrate back to the interstitial fluid. A gradient is produced between the interstitial fluid and that of the filtrate. Water will always move out from any point in the descending limb because the surrounding interstitial fluid will always be hyperosmotic.

2. The surrounding capillaries do not affect this gradient. It moves opposite that of the limb of the loop of Henle.
 - a. In the Distal tubule: filtrate is hypoosmotic.
 - b. In the collecting duct: because of permeability to water the filtrate becomes hyperosmotic along the way. High concentration of urea in the filtrate allows its diffusion to maintain the gradient. Even though the filtrate lost some solute along the way the filtrate produced is still hyperosmotic compared to interstitial fluid of the body.

PRACTICE AND ENRICHMENT

Swim and Pee

The discussion can be related to why people tend to pee too much when they are swimming. The teacher can ask the student's experience in terms of this scenario or during times when the temperature are high or low and its implication on urine formation.

EVALUATION (20 MINS)

The teacher can make his/her own list of questions that will allow students to practice critical thinking skills. The quiz can be administered by pairs or individually. Paired or grouped quiz allows the student to further discussed the lesson and learn from their peers. The teacher can formulate open-ended questions or multiple-choice exam from the lesson. The following are guide questions which can help the teachers in formulating their questionnaires.

1. What is the difference between osmoconformer and osmoregulator?
2. What is the difference between thermoconformer and thermoregulation?
3. Why is the term cold-blooded a misconception? Explain.
4. Why do thermoregulators require more nutrition than same size osmoregulators? Explain.
5. What are the different nitrogenous wastes?
6. How do the different nitrogenous wastes impact the amount of water conserved in the body of animals?
7. How does an organism's habitat impact the kind of nitrogenous wastes they have in conservation of water?
8. How does the knowledge of countercurrent exchange mechanism explain the recycling of water and heat in an organism?
9. Why do kidney stones form if an individual does not excrete urine? Explain.
10. How does your knowledge of urine formation and nutrition/diet will prevent you from forming kidney stones? Explain.

REFLECTION (HOMEWORK FOR NEXT MEETING)

1. Which of the topics interest you the most? Why?
2. Which of the topics interest you the least? Why?
3. Did the activities help you understand the topic (Y/N)? Explain your answer.
4. Did you see the significance/ connection of the topic in your life?

Lesson 38: How Animals Survive (Immune System)

Content Standard

The learners demonstrate an understanding on immune system, and the defense from disease.

Performance Standard

The learners shall be able to make a presentation of some diseases that are associated with the various organ systems.

Learning Competencies

The learners explain the different metabolic processes involved in the various organ systems and describe the general and unique characteristics of the different organ systems in representative animals (**S11/12LT-IIIaj-20 and S11/12LT-IIIaj-21**)

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Know the structure function relationship in the various organ systems
2. Able to synthesize the various functions of the organ systems in the day-to-day activity of an individual
3. Used their knowledge of physiological processes to understand the different diseases associated with the organ systems

LESSON OUTLINE

Introduction	Communicating Learning Objectives	5
Motivation	"Inay, Inay, May sakit ako."	10
Instruction	Lesson Proper	40
Practice	Debate	20
Evaluation	Quiz	15
Reflection	End of the Topic Questions	

Materials

Table of codons, school supplies

Resources

- (1) Reece JB, Urry LA, Cain ML. 2010. Campbell Biology 10th. San Francisco(CA):Pearson Benjamin
- (2) https://www.nobelprize.org/nobel_prizes/medicine/laureates/2011/steinman_lecture.pdf

INTRODUCTION (5 MINS)

Communicate Learning Objectives

1. Introduce the learning objective by writing it on the board, then give the students 5 minutes to write down on a piece of paper what they already know or what they expect to learn under the specified topics:
 - a. Know the structure function relationship in the various organ systems
 - b. Able to synthesize the various functions of the organ systems in the day-to-day activity of an individual
 - c. Used their knowledge of physiological processes to understand the different diseases associated with the organ systems

MOTIVATION (10 MINS)

Inquire about the diseases/illnesses that they have acquired that they can remember. Ask them about how did they contract it, how long did they have it, how did they feel when they had it, what are the symptoms they had and how they were able to get healthy. The article on the discovery and function of the dendritic cells can be a jump-off point, an enrichment material or the guide in the discussion of the immune system.

INSTRUCTION (40 MINS)

Pathogen is a foreign substance, living or non-living, which elicits an immune response from an organism. It can be a pollen which can cause allergic reaction, a helminth (worm) which is a parasite, a bacteria or virus which can cause different diseases or illnesses. Some illnesses that we experience are immune response from these pathogens, such as fever which is a defense mechanism of our body against some pathogens, mucus production for trapping pathogens and other such responses.

Innate and Adaptive immunity

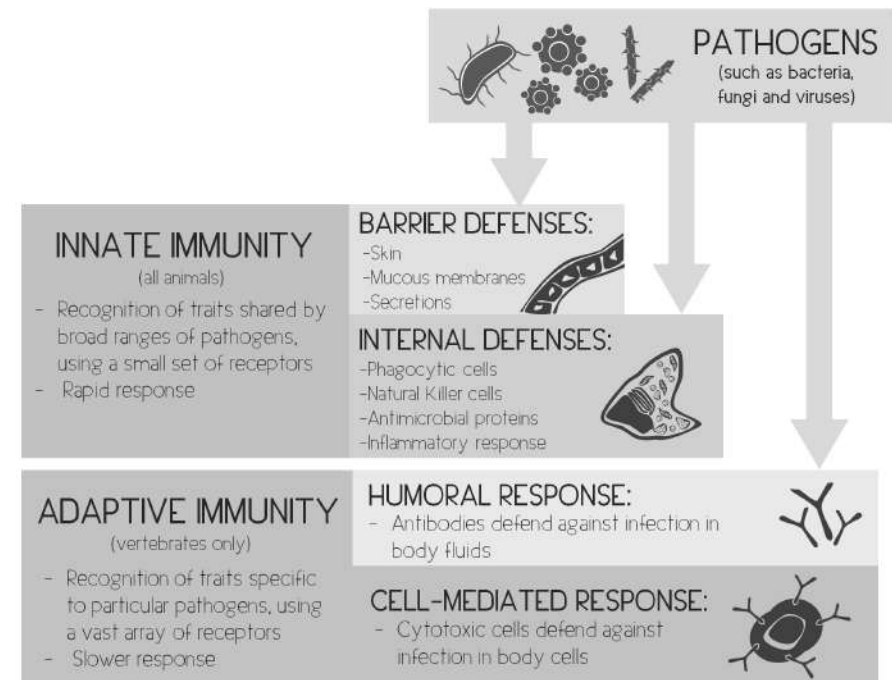
Innate immunity is the inherent ability of an organism to fight pathogens which bring about certain diseases. Evolutionary adaptation has allowed organisms to fine tune their innate immunity against possible pathogens, that is why we are able to activate an immune response even if we have not acquired a certain disease before. In adaptive immunity, organisms are able to launch specific immune response which can change and adapt to the disease-causing pathogen. This adaptive immunity is important, as it can modify its immune response in defense against the changes which can occur in the pathogen.

Teacher Tip:

Through this introduction, you will have an idea where to start or how you will approach your discussion. This will give you an idea where to mainly focus on the given topics to properly managed your time.

Teacher Tip:

The teacher can start the lesson by introducing an everyday tool/object he or



Innate immunity attacks wider range of pathogen, thus, is not very specific but response is rapid. Meanwhile, adaptive immunity is specific but has a slower response rate.

Barrier defenses are made up of the skin, mucus membranes and various secretions. Skin, which is covered by a tightly packed cells called epithelial cells physically prevent the entrance of pathogens. Damage, such as in wounds, allows pathogens to enter an organism via the skin. For body parts which can serve as an entrance to the body such as ducts in the eyes, nostrils, urogenital region, and anus, the mucus membrane serve as barrier by creating an environment which is not optimum to the growth of certain bacteria and other pathogens. Secretions, such as the sweat, are acidic or hypertonic which can destroy or neutralize some pathogens.

In the instance that a pathogen is able to enter and invade the body, there are internal defenses which can be activated that can neutralize the pathogen. Same with the barrier response, these are not specific and as such can affect a large of the body or the whole body itself, in case of fever. Mostly, internal defense is characterized phagocytic cells which eat pathogens regardless of what they are, which in some cases increases the rate of infection. The inflammatory response, activates different internal defenses in case of infection, below is an illustration which sums up the whole process of inflammatory response.

In an inflammatory response, phagocytic cells, antimicrobial proteins, and other substances are activated to contain an infection. Histamines are substances which initiate an inflammatory response, which results in the swelling of an area and increase in temperature of a localized area or in cases of a fever the increase temperature of the whole body to neutralize a pathogen. Heat destroys the protein of a pathogen, which is usually the reason of an infection. Not only heating of the pathogen, but leakage of cells and antimicrobial proteins, especially phagocytic cells and antibodies, aids in the destruction of the caused of inflammation.

THE SPECIFIC IMMUNE RESPONSE

The specific immune response is characterized by specific cells which react to specific protein receptors from pathogens. Activation of proteins (humoral response) or activation of cells with lysing capability (cell-mediated response) are characteristic of the specific immune response. Below is an illustration which summarizes the whole specific immune response.

Teacher Tips:

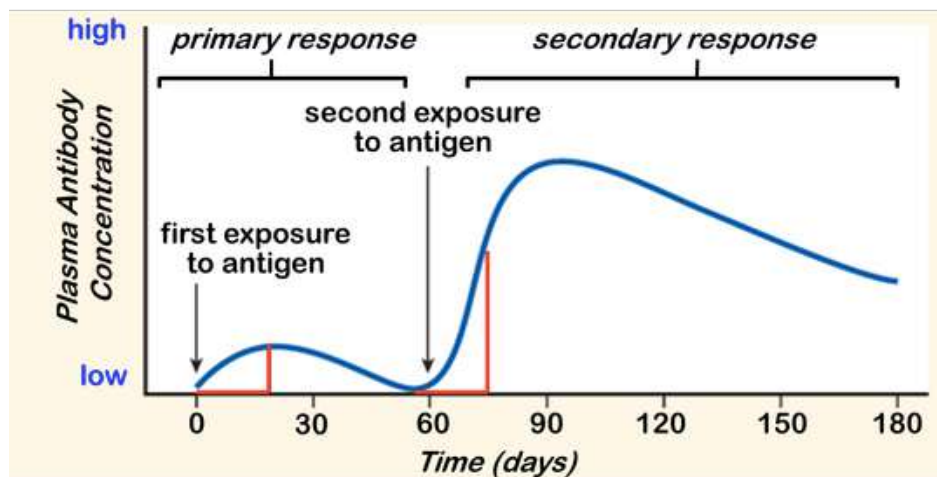
The new terms in the lesson proper should be addressed first, either as an assignment for recitation or as another activity to lessen banking of terms. Even if the lesson calls for a lot of familiarization, dialogical discussion can occur if the students are equipped beforehand of the topic to be studied.

The teacher should be able to define what a pathogen is, and how can it cause an immune response.

The three lines of defense should be explained clearly, in order for the students to understand the need for them, such as why is there a need for a barrier response when we have specific immune responses.

The specific immune response should be distinguished in order to clarify their mechanism of action, specifically the formation of antibodies for humoral response and the activation of second line of defense for cell-mediated response.

Memory cells are important in order to increase the speed of an immune response. Also to remember the activation of a specific immune response. This also has an implication on the mechanism of action of HIV.



The graph shows that upon first infection, the specific immune response is slow to react, thus, resulting to longer infection. But this builds up memory to this particular disease, as a result, a second infection can be shorter as the cells of the specific immune response can launch a more specific attack.

Active and Passive Immunity

Specific immune response can be a result of active immunity which is a result to exposure to a specific pathogen. It can either be natural or artificial, in the case of vaccine, wherein pathogens are weakened and exposed to an individual. Meanwhile, passive immunity is a specific immune response transferred by the mother to a child, which can develop as the child matures.

PRACTICE AND ENRICHMENT

The class can have a discussion in terms of absences as a result of transmission of diseases such as bulutong tubig (chicken pox), colds, flu and other infectious diseases during a school year. Students can give their reason why they did not contract the illness, or why they did contract it in terms of the lesson learned. The teacher can also relate, why individuals who live in a very clean environment are more prone to infection than those who are not.

Teacher Tips:

The new terms in the lesson proper should be addressed first, either as an assignment for recitation or as another activity to lessen banking of terms. Even if the lesson calls for a lot of familiarization, dialogical discussion can occur if the students are equipped beforehand of the topic to be studied.

The teacher should be able to define what a pathogen is, and how can it cause an immune response.

The three lines of defense should be explained clearly, in order for the students to understand the need for them, such as why is there a need for a barrier response when we have specific immune responses.

The specific immune response should be distinguished in order to clarify their mechanism of action, specifically the formation of antibodies for humoral response and the activate of second line of defense for cell-mediated response.

Memory cells are important in order to increased the speed of an immune response. Also to remember the activation of a specific immune response. This also has an implication on the mechanism of action of HIV.

Image source:

<https://pmgbiology.files.wordpress.com/2014/04/adaptiveimmunitymemory.png?w=540&h=350>

EVALUATION (20 MINS)

The teacher can make his/her own list of questions that will allow students to practice critical thinking skills. The quiz can be administered by pairs or individually. Paired or grouped quiz allows the student to further discussed the lesson and learn from their peers. The teacher can formulate open-ended questions or multiple-choice exam from the lesson. The following are guide questions which can help the teachers in formulating their questionnaires.

1. What is a pathogen?
2. What are the different levels of defense employed by the body against pathogens?
3. Why is there a need for an internal barrier if it cannot fight off pathogens through specific responses?
4. What are the two different specific immune responses?
5. How are the specific immune responses different from each other?
6. How does second line of defense play a role in the specific immune response?
7. What is the importance of memory response of the immune system?
8. What is a vaccine? How does it stimulate memory immune response?
9. If there are valid reasons to fear vaccines, what are they? Explain.
10. What is the difference between active and passive immunity? How is active immunity differentiated?

REFLECTION (HOMEWORK FOR NEXT MEETING)

1. Which of the topics interest you the most? Why?
2. Which of the topics interest you the least? Why?
3. Did the activities help you understand the topic (Y/N)? Explain your answer.
4. Did you see the significance/ connection of the topic in your life?

Lesson 39: How Animals Survive (Hormones)

Content Standard

The learners demonstrate an understanding as to how hormones govern body activities.

Performance Standard

The learners shall be able to make a presentation of some diseases that are associated with the various organ systems

Learning Competencies

The learners explain the different metabolic processes involved in the various organ systems describe the general and unique characteristics of the different organ systems in representative animals **(S11/12LT-IIIaj-20 and S11/12LT-IIIaj-21)**

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Know the structure function relationship in the various organ systems
2. Able to synthesize the various functions of the organ systems in the day-to-day activity of an individual
3. Used their knowledge of physiological processes to understand the different diseases associated with the organ systems

LESSON OUTLINE

Introduction	Communicating Learning Objectives	5
Motivation	Alin, Alin, Alin ang Naiba	10
Instruction	Lesson Proper	40
Practice	Debate	20
Evaluation	Quiz	15

Reflection End of the Topic Questions

Materials

Table of codons, school supplies

Resources

- (1) Reece JB, Urry LA, Cain ML. 2010. Campbell Biology 10th. San Francisco(CA):Pearson Benjamin
- (2) https://www.nobelprize.org/nobel_prizes/medicine/laureates/2011/steinman_lecture.pdf

INTRODUCTION (5 MINS)

Communicate Learning Objectives

1. Introduce the learning objective by writing it on the board, then give the students 5 minutes to write down on a piece of paper what they already know or what they expect to learn under the specified topics:
 - a. Know the structure function relationship in the various organ systems
 - b. Able to synthesize the various functions of the organ systems in the day-to-day activity of an individual
 - c. Used their knowledge of physiological processes to understand the different diseases associated with the organ systems

MOTIVATION (10 MINS)

Tell a story of a memorable story of changes in your body that occurred during your adolescent stage. After sharing this, ask the class to share some of the changes that they are experiencing or have experienced when they reached this stage.

INSTRUCTION (40 MINS)

Hormones are substances which can cause a reaction to a cell, in Greek it literally means to excite. It is secreted into extracellular fluid such in blood or lymph and transported to target cells to elicit a specific response, which can be rapid or slow. The growth and development of the body are examples of slow and long term effect of a hormone while circadian rhythm which is responsible for the sleep-and-wake cycles respond to a more rapid response to a hormone.

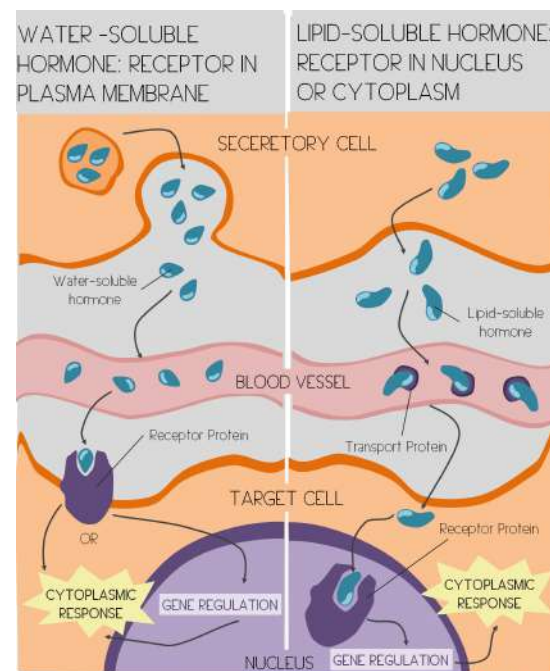
Hormones can either be water-soluble or fat-soluble which has implication on how response mechanism in cells is activated. The characteristics of the cell membrane, which is a selective membrane chooses the molecules which can go in and out of the cells. The lipid bilayer of the cell, thus, prevent the free movement of water-soluble hormones, while, fat-soluble hormones can easily pass through a cell membrane.

Teacher Tip:

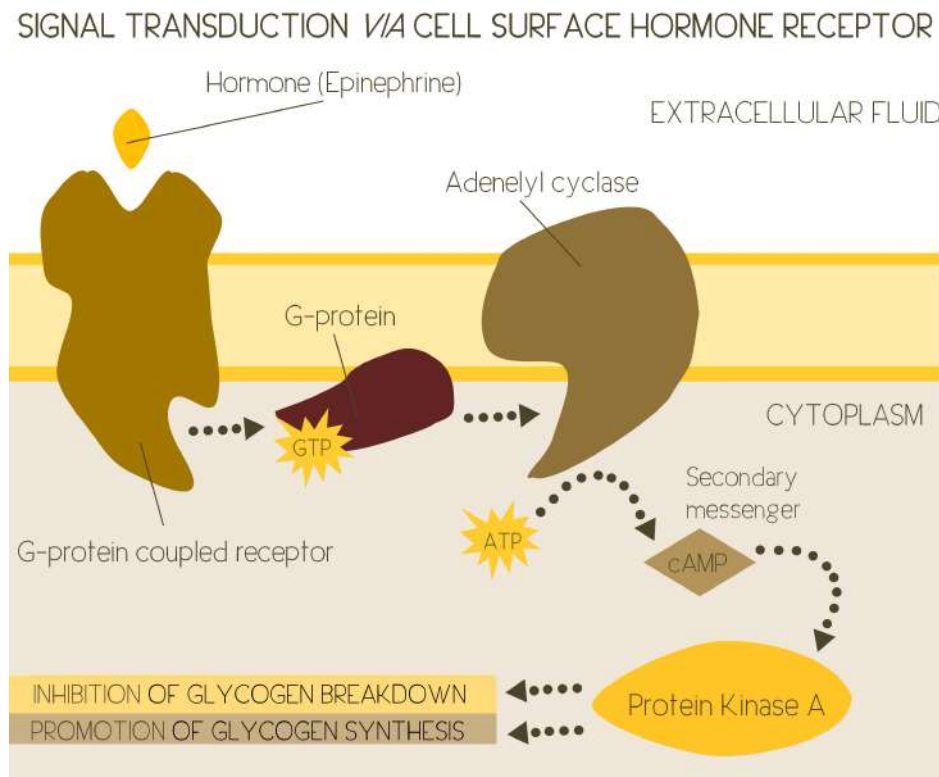
Through this introduction, you will have an idea where to start or how you will approach your discussion. This will give you an idea where to mainly focus on the given topics to properly managed your time.

Teacher Tip:

The teacher can start the lesson by introducing an everyday tool/object he or she brought in the class and associate it to its corresponding function. This can then be related to the lesson.



The illustration in the previous page shows the location of reception of the two types of hormones. Reception is the process of a signal molecule to bind to receptor molecules. The inability of water-soluble hormones to pass through the cell membrane requires them to activate response from outside of the cell. Thus, receptor proteins which activate cell responses are found on the cell membrane of the cell, this activates signal transduction pathway. Meanwhile, the ability of fat-soluble hormones or steroid hormones to pass through the cell membrane allows them to initiate cell response inside the cell. Their receptors are found on the nuclear membrane which can initiate gene expression. Thus, as a result, steroid hormones can have a longer, lasting effect than peptide hormones.



Above, shows the general reaction in both peptide and steroid hormones. Lastly, a hormone can have different effects depending on the target cells, such in the case of epinephrine which can either increase or decrease blood flow. These varied responses is due to the different characteristics of cells or the difference in the receptors of cells. Also, a hormone can follow a simple endocrine pathway or a simple neuroendocrine pathway which involves the nervous system.

Teacher Tips:

The new terms in the lesson proper should be addressed first, either as an assignment for recitation or as another activity to lessen banking of terms. Even if the lesson calls for a lot of familiarization, dialogical discussion can occur if the students are equipped beforehand of the topic to be studied.

Critical here is the discussion of the structure of the cell membrane, especially a recall of the fluid mosaic model. This will aid in the understanding how hormones activate a response in the cell.

Their knowledge of chemistry, especially how substances are dissolved will explain how some hormones initiate a response on the cell membrane while others on the nuclear membrane.

The discussion on the metamorphosis of insects, show how interaction of different hormones affect the changes that can occur in animal. Balancing of these hormones can inhibit or allow the reaction to occur.

In an endocrine pathway, the reaction involves an endocrine cell, which releases the hormone to the bloodstream or the lymphatic system, which is able to attach to receptors of a target cell. Meanwhile, in a neuroendocrine pathway, the nervous system is involved in the released of hormone for the reception on/in a target cell.

Hormonal response is not unique to humans or mammals, this is evident in the metamorphosis of some insects. Metamorphosis is controlled by the interaction of hormones which initiates changes in the organism. The brain hormone stimulates an activator hormone called prothoracicotropic hormone (PTTH), which activates a hormone called ecdysteroid. Ecdysteroid stimulates changes from larva to adult. Another hormone, the juvenile hormone (JH) affects the changes in the insect, wherein, high amounts of JH prevents metamorphosis, while low amount allows the action of ecdysteroid. Below, is the mechanism of action of the hormones in the metamorphosis of insects.

PRACTICE AND ENRICHMENT

In order to show the concept of mechanism of action of peptide and steroid hormones, the teacher can ask the class to dissolve different materials, such as sugar, candies, fat, and others in water, oil and other solvent. This will show that substances dissolve like substances, thus, illustrating how steroid hormones are able to pass through the cell's membrane.

EVALUATION (20 MINS)

The teacher can make his/her own list of questions that will allow students to practice critical thinking skills. The quiz can be administered by pairs or individually. Paired or grouped quiz allows the student to further discussed the lesson and learn from their peers. The teacher can formulate open-ended questions or multiple-choice exam from the lesson. The following are guide questions which can help the teachers in formulating their questionnaires.

QUIZ

1. What are hormones?
2. What are the different types of hormones?
3. How are the different hormones initiate responses in a cell?
4. What is the site for the initiation of the cell response for both kinds of hormones?
5. What is a tropic hormone?
6. If hormones are molecules in small amounts, how does the cell amplify its effect? Explain.
7. How does the circulatory and lymphatic system play a role in the function of the endocrine system?
8. How does the nervous system play a role in the function of the endocrine system?
9. What is the importance of a positive feedback mechanism? Negative feedback mechanism? Explain.
10. Using your concept of hormones and the feedback mechanisms, how can you explain the action of insulin in balancing the sugar in our blood?

REFLECTION (HOMEWORK FOR NEXT MEETING)

1. Which of the topics interest you the most? Why?
2. Which of the topics interest you the least? Why?
3. Did the activities help you understand the topic (Y/N)? Explain your answer.
4. Did you see the significance/ connection of the topic in your life?

Lesson 40: How Animals Survive (Nervous System)

Content Standard

The learners demonstrate an understanding on the nervous system.

Performance Standard

The learners shall be able to make a presentation of some diseases that are associated with the various organ systems.

Learning Competencies

The learners explain the different metabolic processes involved in the various organ systems describe the general and unique characteristics of the different organ systems in representative animals **(S11/12LT-IIIaj-20 and S11/12LT-IIIaj-21)**

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Know the structure function relationship in the various organ systems
2. Able to synthesize the various functions of the organ systems in the day-to-day activity of an individual
3. Used their knowledge of physiological processes to understand the different diseases associated with the organ systems

LESSON OUTLINE

Introduction	Communicating Learning Objectives	5
Motivation	Pass the Message	10
Instruction	Lesson Proper	40
Practice	Debate	20
Evaluation	Quiz	15
Reflection	End of the Topic Questions	

Materials

Table of codons, school supplies

Resources

(1) Reece JB, Urry LA, Cain ML. 2010. Campbell Biology 10th. San Francisco(CA):Pearson Benjamin

INTRODUCTION (5 MINS)

Communicate Learning Objectives

1. Introduce the learning objective by writing it on the board, then give the students 5 minutes to write down on a piece of paper what they already know or what they expect to learn under the specified topics:
 - a. Know the structure function relationship in the various organ systems
 - b. Able to synthesize the various functions of the organ systems in the day-to-day activity of an individual
 - c. Used their knowledge of physiological processes to understand the different diseases associated with the organ systems

Teacher Tip:

Through this introduction, you will have an idea where to start or how you will approach your discussion. This will give you an idea where to mainly focus on the given topics to properly manage your time.

MOTIVATION (10 MINS)

Pass the Message Game

There are two types of Pass the Message Game the teacher can ask the students to play:

1. The teacher can group the class and ask them to line up. The first persons in the line will be asked a question which they will answer. They will pass the answer to the person next in line. The message should reach the last person, who will then run towards the teacher to give the answer. The group which garners the most score wins the game.
2. The teacher can ask the whole class to make a circle. Ask the class to hold the arm of the person next/beside them. The message is passed by using the index finger in tapping the arm of the next person, where the message will be passed. After which, the teacher will choose an "it" who will try to catch the messenger. The game will repeat if the message is transmitted to the intended recipient, if the "it" was able to catch the messenger that person will be the new "it" and the game starts again. The teacher can choose how many times the game will be played.

Teacher Tip:

The teacher can start the lesson by introducing an everyday tool/object he or she brought in the class and associate it to its corresponding function. This can then be related to the lesson.

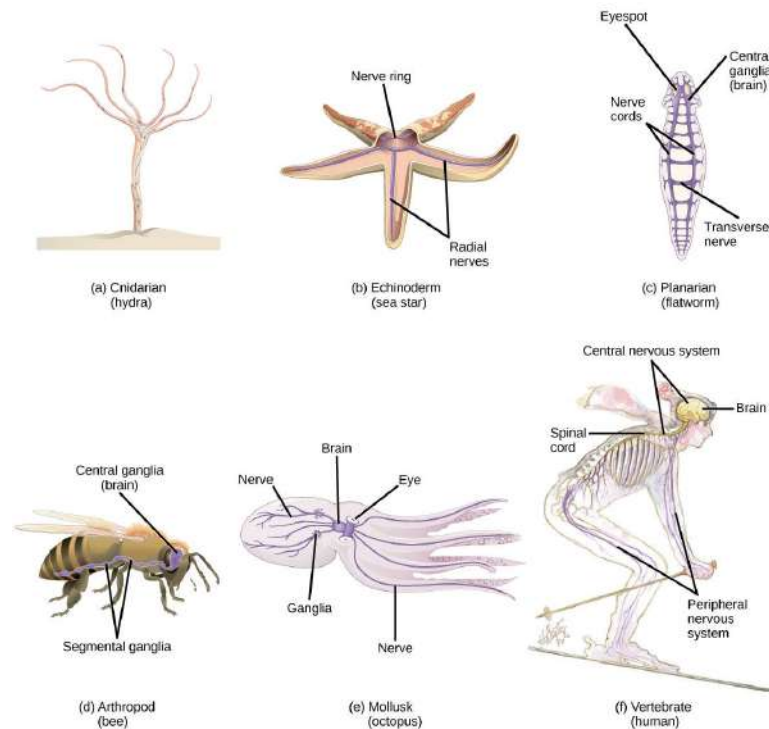
INSTRUCTION (40 MINS)

From the previous lesson, a chemical substance such as a hormone can elicit a response from a cell. This is initiated by a cascade of reactions such as in the signal transduction pathway in steroid hormones. Cell response as a result of hormone activation is a slow process, for instances in which a response should be immediate another organ system is responsible, the nervous system.

The nervous system is composed of circuits of nervous tissue and supporting cells. The functional unit of the nervous system is the nerve, which is composed of neurons that have extensions for transmission

of messages. The extensions of neurons are called dendrites and axons, wherein, axons transmit message away from the cell body of the neuron, while, dendrites transmit messages towards the cell body of neurons. Supporting cells called glia (glial cells), function in metabolic, structural, metabolic and other activities of the neuron. The Schwann cells, is an example of a glia, which surrounds the axon of neurons for more efficient transmission of message.

The nervous system has evolved in increasing complexity throughout the different groups of animals. Connections among the neurons has increased, as seen in the development of the nervous system from a simple nerve net to a system with ganglia (group of neuron) to encephalized organisms where concentration of neurons are centered in a head. Below shows the changes in the nervous system of organisms:



The nervous system is further distinguished by the location of the neurons within the system. The central nervous system is composed of the brain and spinal cord, while, the peripheral nervous system is composed of corresponding structures outside of this two organs of the nervous system.

Teacher Tips:

The new terms in the lesson proper should be addressed first, either as an assignment for recitation or as another activity to lessen banking of terms. Even if the lesson calls for a lot of familiarization, dialogical discussion can occur if the students are equipped beforehand of the topic to be studied.

The structure of a neuron in relation to its function will form the basis of how the nervous system works. As messages are transmitted in long distances, there is a need to have structure which can reach long distances.

The clumping/grouping of neurons, means the organization of the information reception, processing and distribution.

The protein gates/channels allow ions to move in and out of the neuron, creating the membrane potential (voltage) which becomes the message that moves along the neuron. If the voltage is not created along the membrane, then the propagation of the message stops.

Image source:

http://philschatz.com/biology-book/resources/Figure_35_01_01.jpg

The central nervous system is responsible for data/information processing which is gathered by the peripheral nervous system. Upon processing, the CNS transmit the message again to the PNS, which then convey the message for the appropriate response. The PNS is further divided, based on its function, into the motor system and the autonomic nervous system which is diagramed above. The motor system controls skeletal muscles or voluntary muscles, while the autonomic nervous system functions in the control of involuntary muscles (cardiac, smooth muscles) and glands. The sympathetic and parasympathetic divisions mostly have antagonistic functions, while the enteric division function in digestive control. The diagram below summarizes the function of the parasympathetic and sympathetic division of the autonomic nervous system.

It should not be misconceived that the motor neurons are only responsible for voluntary action as a result of its control of voluntary muscles. Involuntary action, such in the case of a reflex reaction is governed by involuntary action of voluntary muscles. As the response is rapid and fast, processing of the information lies within the spinal cord, there is no time for information processing in the brain.

Message that is received, processed, and transmitted for a response is a result of electrochemical reactions that is governed by concentration or potential differences across the membrane of the neuron. This is controlled by the selective permeability of the cell, wherein protein channels/gates allow/inhibit the movement of ions such as K^+ and Na^+ which creates membrane potential (voltage) that is transmitted as the message throughout the nervous system.

In a nutshell, the different protein channels and gates found along the membrane of a neuron allows it to take in and release ions which changes the voltage (membrane potential) of the neuron's cell membrane. This voltage is the message that the neuron transmits throughout the animal's body, that's why a dietary problem involving loss of ions can result in the ability to move or function properly. For example, if a person has diarrhea, there is a problem in terms of moving muscles as there is not enough ions to create the message for moving. A diet that includes banana, ensures that ions needed for impulse transmission is present in the body.

The series of changes in membrane potential (polarization and depolarization) results in the one-way transmission of message as an electrical message across the neuron. The transmission of message is further summarized by the following illustration:

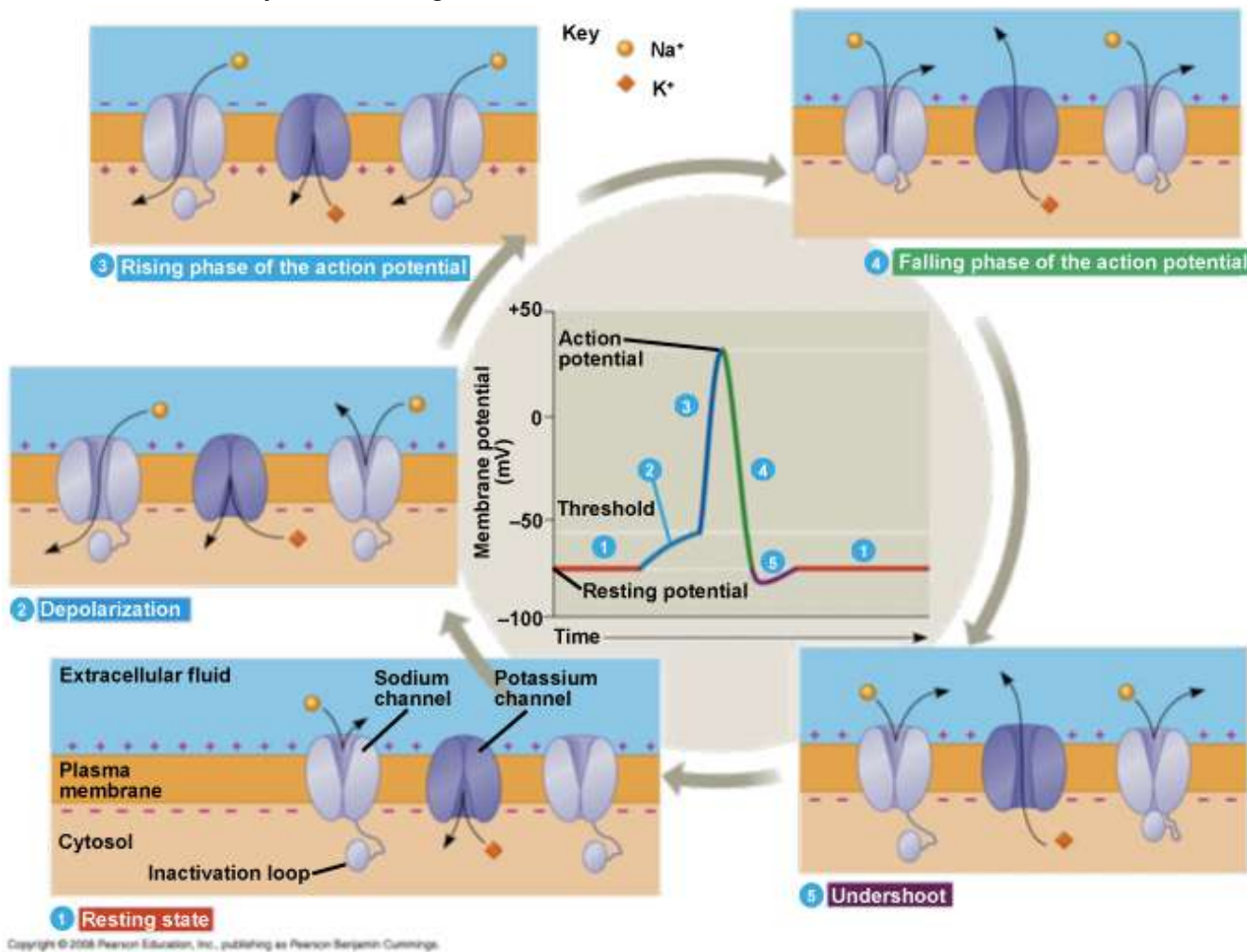


Image source:

<http://home.sandiego.edu/~gmorse/2011BIOL221/studyguidefinal/actionpotential.jpg>

PRACTICE AND ENRICHMENT

Relate the motivation activity to the generation of impulse throughout the neuron and more importantly, throughout the body. By allowing the student to discuss the lesson in terms of the game, the teacher will be able to discern if the class understood the topic on their own terms.

EVALUATION (20 MINS)

The teacher can make his/her own list of questions that will allow students to practice critical thinking skills. The quiz can be administered by pairs or individually. Paired or grouped quiz allows the student to further discussed the lesson and learn from their peers. The teacher can formulate open-ended questions or multiple-choice exam from the lesson. The following are guide questions which can help the teachers in formulating their questionnaires.

1. Draw the structure of a neuron.
2. In terms of the structure and function relationship in neurons, why do they have extensions such as the dendrites and the axon? Explain.
3. Why is the clumping of nervous tissue a sign of complexity in animals, especially the development of the brain?
4. How does reflex action work?
5. How can the nervous system be divided?
6. How can the Peripheral Nervous System (PNS) be divided? What is/are the function/s of these divisions?
7. What role do protein channels and gates play in the creation and transmission of information?
8. Why do we say that impulse transmission is the creation of electrochemical message?
9. Why is a gradient needed in impulse transmission?
10. What is the implication of a lack or a diet low in minerals in impulse transmission? Explain.
11. What kind of local food should we include in our diet to ensure that nerve impulse transmission will be properly generated and propagated? Explain.

REFLECTION (HOMEWORK FOR NEXT MEETING)

1. Which of the topics interest you the most? Why?
2. Which of the topics interest you the least? Why?
3. Did the activities help you understand the topic (Y/N)? Explain your answer.
4. Did you see the significance/ connection of the topic in your life?

Lesson 41: How Animals Survive (Locomotion)

Content Standard

The learners demonstrate an understanding of the body in motion.

Performance Standard

The learners shall be able to make a presentation of some diseases that are associated with the various organ systems.

Learning Competencies

The learners explain the different metabolic processes involved in the various organ systems describe the general and unique characteristics of the different organ systems in representative animals **(S11/12LT-IIIaj-20 and S11/12LT-IIIaj-21)**

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Know the structure function relationship in the various organ systems
2. Able to synthesize the various functions of the organ systems in the day-to-day activity of an individual
3. Used their knowledge of physiological processes to understand the different diseases associated with the organ systems

LESSON OUTLINE

Introduction	Communicating Learning Objectives	5
Motivation	Send Me Up	10
Instruction	Lesson Proper	40
Practice	Debate	20
Evaluation	Quiz	15
Reflection	End of the Topic Questions	
Materials		
Table of codons, school supplies		
Resources		
(1) Reece JB, Urry LA, Cain ML. 2010. Campbell Biology 10th. San Francisco(CA):Pearson Benjamin		

INTRODUCTION (5 MINS)

Communicate Learning Objectives

1. Introduce the learning objective by writing it on the board, then give the students 5 minutes to write down on a piece of paper what they already know or what they expect to learn under the specified topics:
 - a. Know the structure function relationship in the various organ systems
 - b. Able to synthesize the various functions of the organ systems in the day-to-day activity of an individual
 - c. Used their knowledge of physiological processes to understand the different diseases associated with the organ systems

MOTIVATION (10 MINS)

1. Using regular found objects in the classroom, like meter stick, cord, cartolina, and other more objects, ask the class to construct a simple machine which can lift up a given object/token. The token can be a styropor, a box or any object which will not break if it falls. The goal of the game is to lift the object at a certain height which the teacher will set.
2. The teacher can give a bonus point for the winner or for the entire group which reach the set height.

INSTRUCTION (40 MINS)

The activity conducted as motivation for this lesson summarizes how locomotion is effected by the action of muscles against an organic lever, the skeleton. In order to understand the mechanism of locomotion, we need to understand the physiological process and the structure of the muscle responsible for movement, the skeletal muscle.

The skeletal muscle is organized from its largest structure (the muscle tissue itself) to its functional unit (the sarcomere) as a repeating longitudinal structure that is bound together. In a nutshell, it is like a "walis tingting" or a broomstick, where the strength of the structure is a function of the bound muscle cells. Below is the illustration of the skeletal muscle and the corresponding structures necessary for contraction.

Teacher Tip:

Through this introduction, you will have an idea where to start or how you will approach your discussion. This will give you an idea where to mainly focus on the given topics to properly managed your time.

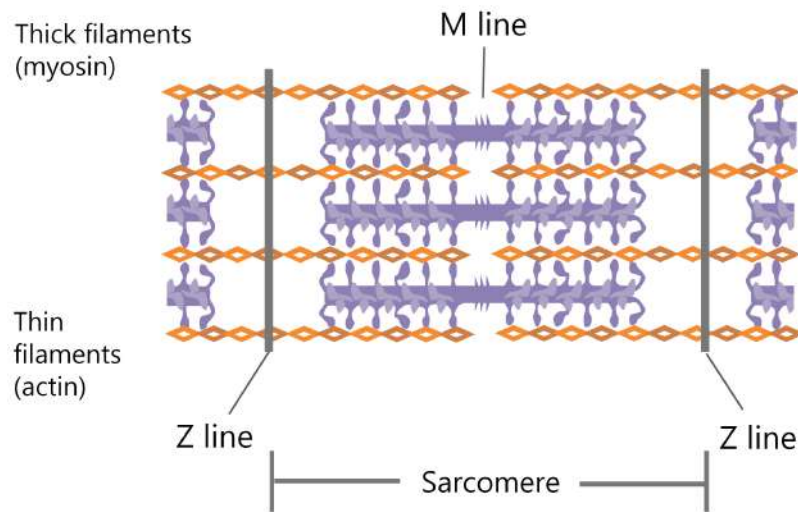
Teacher Tip:

The teacher can start the lesson by introducing an everyday tool/object he or she brought in the class and associate it to its corresponding function. This can then be related to the lesson.

Notes:

The new terms in the lesson proper should be addressed first, either as an assignment for recitation or as another activity to lessen banking of terms. Even if the lesson calls for a lot of familiarization, dialogical discussion can occur if the students are equipped beforehand of the topic to be studied.

The longitudinal arrangement of the muscular system is very important in the understanding of the lesson. The teacher must be able to clarify its importance before he/she can proceed, as this forms the foundation of the whole mechanism of reaction.



Notes:

The sarcomere, embodies the contraction that occurs in the body, if the teacher is able to relate the change in its length to the contraction of the muscle, then the discussion will be easier to understand.

The lever/pulley activity is important in this lesson as it shows how the muscle acts on the skeleton (lever) and the type of action it creates (pull). This encapsulates the whole discussion.

From the picture above, the repeating longitudinal structure is observed from the muscle, to a bundle of muscle fiber, a muscle fiber (muscle cell), a myofibril and the sarcomere. Contraction is possible because of the structural organization of protein molecules that makes up the sarcomere. As seen from the right picture above, arms of the thick filaments move along the thin filaments, pulling both Z lines at the ends into the middle. When contraction occurs, the sarcomere shortens and this is reflected in the contraction of a muscle (you can ask the students to flex their biceps, and ask them if their muscle shortened). In terms of the molecular and physiological process of contraction, nerve impulse transmission is needed to depolarize the cell membrane of the muscle to stimulate contraction.

The reason why a taser or when you get electrocuted stops you from moving is because of simultaneous of contractions of different muscles in your body. When a stimulus (nerve impulse or electricity) arrives around the cell membrane of a muscle cell, it starts a cascade of reaction which releases ions such as K^+ , Na^+ and Ca^{2+} which activates the pulling action of the thick filaments on the thin filaments. The pulling action is called the sliding filament theory, as the thick and thin filaments slide past each other. This action is an all-or-none response, wherein, a muscle will contract or not if the stimulus reaches the threshold stimulation or not. The need for the ions K^+ , Na^+ and Ca^{2+} illustrates why we experience cramps when we lack electrolytes (ions) in our diet, as our muscles are not able to undergo a cycle of contraction and relaxation. The muscles are stuck in a contracted stage. Below illustrates the process of contraction in the sarcomere.

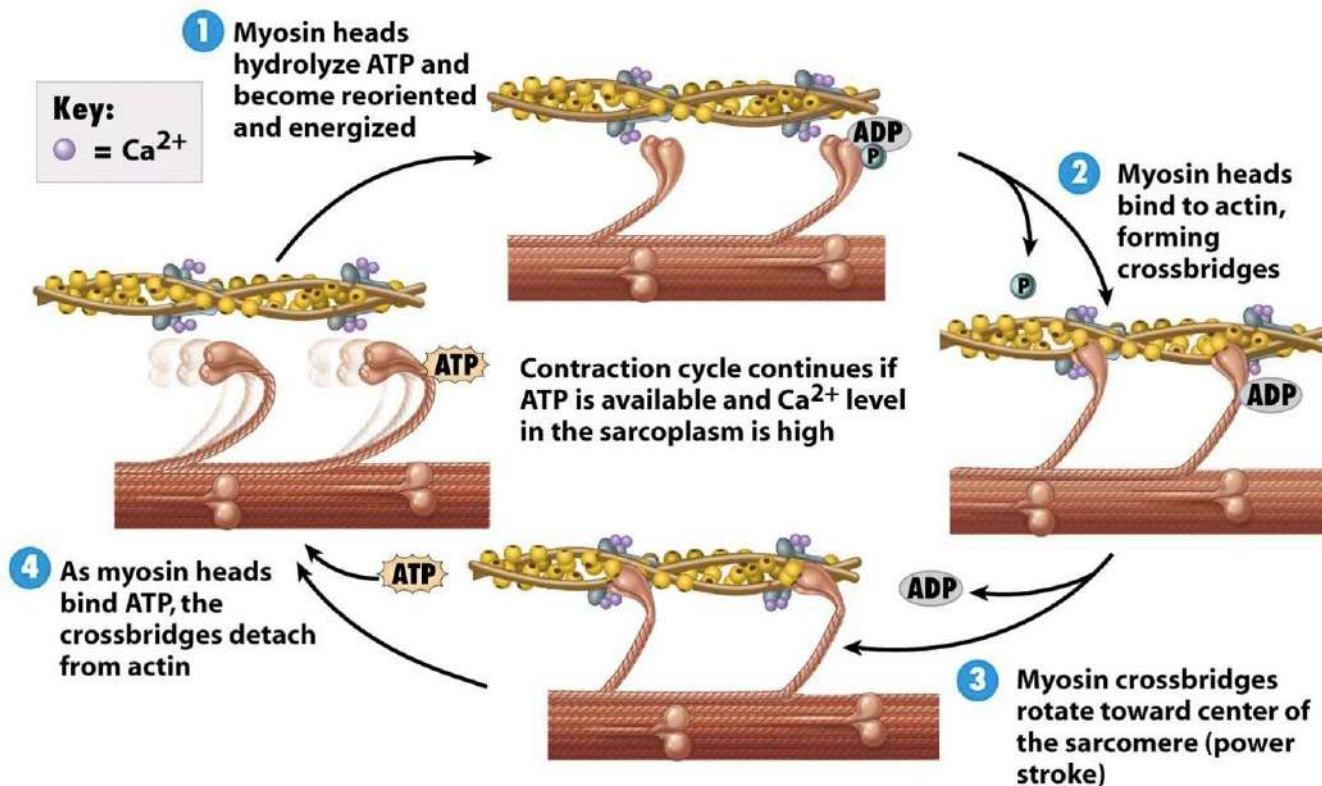


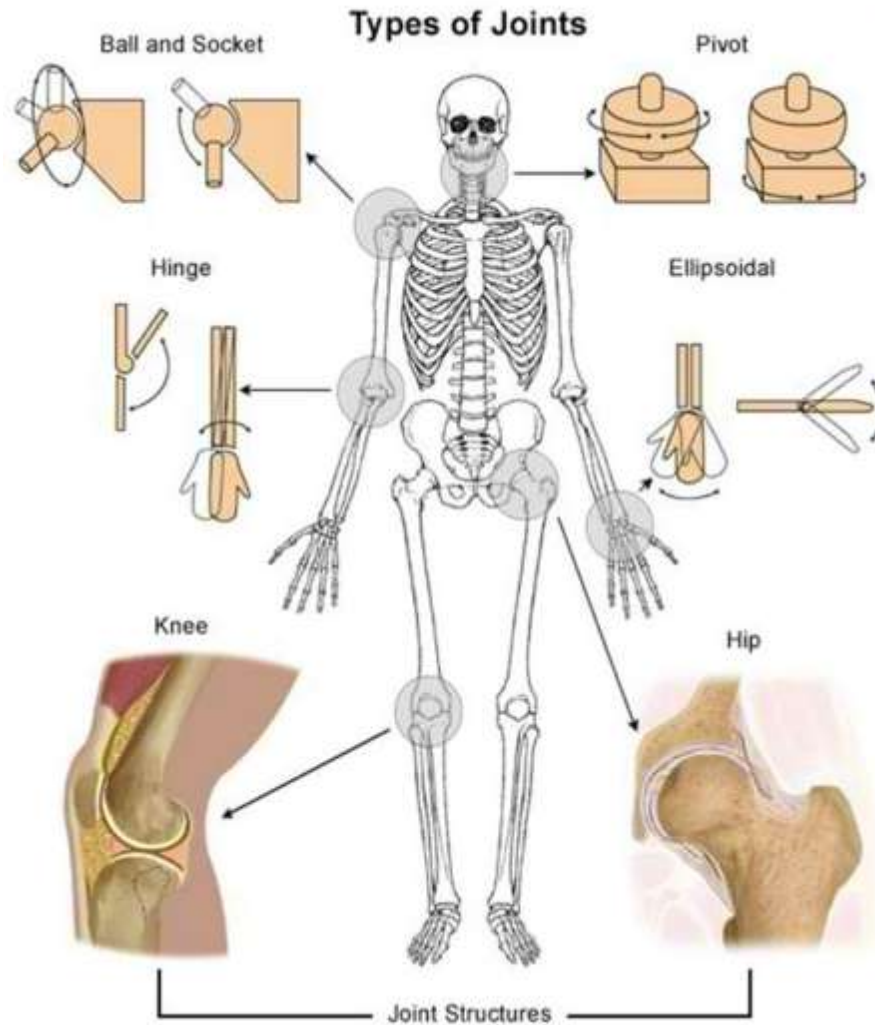
Figure 10-7 Principles of Anatomy and Physiology, 11/e
 © 2006 John Wiley & Sons

Image source:

<http://classconnection.s3.amazonaws.com/1517/flashcards/715536/jpg/picture1.jpg>

As mentioned above, movement or locomotion is a reaction of the contraction of a muscle against an organic lever. All types of movement is a result of pulling action of the muscle, wherein the push to a door is a result of different pulling action of different muscles which result in a pushing action created by the arm. There are different skeletal systems which the muscle can pull on, these are the hydrostatic skeleton, exoskeleton and endoskeleton. In a hydrostatic skeleton, muscles act on a fluid trapped by a cylindrical muscular structure. The contraction of the muscle creates a strong structure which supports movement and strength of a body of an organism, an organ or a particular body part. Examples of a hydrostatic skeleton are the body of a worm and the abdomen.

Meanwhile, a clam's shell is an example of an exoskeleton and the bones and cartilage in a human is an example of an endoskeleton. An endoskeleton should not be misconceived to be only made up of bones, as even in humans, our skeletons are made up of cartilage and bones, while, shark's endoskeleton is made up of cartilage. We have different bones which our muscles can pull to create movement, and the different types of joints are responsible for different movement that our body can create.



PRACTICE AND ENRICHMENT

Relate or explain the motivation activity through your understanding of the lesson proper. Focus on the relationship between the muscles, which creates the forces (pull), and the skeleton, which serves us the biological lever. As there is little time for discussion and activities, this can summarize and determine the understanding of the lesson by the students.

Image source:

<http://anatomyofthefoot.com/types-of-joints-in-human-body.html>

EVALUATION (20 MINS)

The teacher can make his/her own list of questions that will allow students to practice critical thinking skills. The quiz can be administered by pairs or individually. Paired or grouped quiz allows the student to further discussed the lesson and learn from their peers. The teacher can formulate open-ended questions or multiple-choice exam from the lesson. The following are guide questions which can help the teachers in formulating their questionnaires.

1. What kind of force does a muscle produce?
2. What is the function of the skeleton in the production of locomotion in animals?
3. Relate the structure of the muscles to another object in explaining its function? What does the repeating longitudinal structure serve?
4. In the molecular level, how can the shortening of the muscles can be explained during contraction?
5. Why do we need to drink beverages with electrolytes (K^+ , Na^+) or eat a banana to prevent cramping?
6. What are the different types of skeletons?
7. What are the different functions of a skeleton?
8. What kind of adaptation in skeletons can you expect in animals that can fly? Can it be expected in animals that do not fly? Explain.
9. In terms of the circulatory system, in relation to the systems for locomotion, differentiate its complexity comparing individuals who are very active and not active? Explain the difference.
10. In terms of your knowledge in the circulatory, metabolism (ectotherm and endotherm) and locomotion, why can you expect predators to be endotherms? Explain.

REFLECTION (HOMEWORK FOR NEXT MEETING)

1. Which of the topics interest you the most? Why?
2. Which of the topics interest you the least? Why?
3. Did the activities help you understand the topic (Y/N)? Explain your answer.
4. Did you see the significance/ connection of the topic in your life?

Lesson 42: Plant Form and Function and Plant Growth and Development

Content Standard

The learners demonstrate an understanding of plant form and function and plant growth and development.

Performance Standard

The learners shall be able to design a setup on propagating plants using other methods such as hydroponics and aeroponics

Learning Competencies

The learners explain the different metabolic processes involved in the various organ systems and describe the structure and function of the different plant organs (**S11/12LT-IIIaj-22 and S11/12LT-IIIaj-23**)

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Know the structure function relationship in the various organ systems
2. Able to synthesize the various functions of the organ systems in the day-to-day activity of an individual
3. Used their knowledge of physiological processes to understand the different diseases associated with the organ systems

LESSON OUTLINE

Introduction	Communicating Learning Objectives	5
Motivation	Send Me Up	10
Instruction	Lesson Proper	40
Practice	Debate	20
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Reflection	End of the Topic Questions	

Materials

Table of codons, school supplies

Resources

(1) Reece JB, Urry LA, Cain ML. 2010. Campbell Biology 10th. San Francisco(CA):Pearson Benjamin

INTRODUCTION (5 MINS)

Communicate Learning Objectives

1. Introduce the learning objective by writing it on the board, then give the students 5 minutes to write down on a piece of paper what they already know or what they expect to learn under the specified topics:
 - a. Know the structure function relationship in the various organ systems
 - b. Able to synthesize the various functions of the organ systems in the day-to-day activity of a plant
 - c. Used their knowledge of physiological processes to understand the propagation of plants
 - d. Understand and apply the implication of climate change to food production

Teacher Tip:

Through this introduction, you will have an idea where to start or how you will approach your discussion. This will give you an idea where to mainly focus on the given topics to properly manage your time.

MOTIVATION (10 MINS)

1. As an assignment, ask the class/group to research on the different planting season in the Philippines. The groups can focus on different crops in different provinces or the teacher can specifically assign this to the groups.
2. Reporting of the different crops and their impact to the respective region/provinces, such as GDP, economy, etc.
3. The teacher report on the timeline of the different typhoons hitting the Philippines for the past ten years. The teacher can include the heavily affected provinces and when did the typhoons hit these provinces.
4. Based on this, ask the groups on the implication of the typhoon to the farming practices in the country and how can the farmers or the government use this knowledge in mitigating impacts of climate change.

Teacher Tip:

The teacher can relate this motivation activity to his/her experience, especially when he/she was young and typhoons come differently, thus, affecting crops differently compared today.

INSTRUCTION

In order to understand plant form and function, we first need to understand the different form and function of the four main plant tissues. There are four different types of plant tissues, the meristems, ground tissues, dermal tissues and vascular tissues. The latter three tissues form a concentric region in the plant, wherein, the innermost region is made up of vascular tissues, the middle layer is composed of the ground tissues and the outermost layer is made up of dermal tissues. In terms of form and function, the dermal tissues are at the outermost region as they served as protection for the plant such in case of the bark, thorns and other protective structures found the outer portion of the plant. The ground tissue serves as a fill-in space tissue, there are different types of these tissues which function

differently. There is the sclerenchyma tissues, which die at functional maturity, meaning, in order to do their function, these cells die. Wax intrudes the cell, which causes the death of the cell, creating a strong structure which can help in the plant's structural integrity such as in the husk of coconuts or the grainy texture in pears and chico. Another ground tissue is the collenchy, which has the same function as the sclerenchyma, but they are alive at functional maturity. Thus, these tissues can only support young or small plants such as the celery. Lastly, the parenchyma tissues are the most versatile ground tissue as they served different functions. Some store starches such as the tissues that make up a potato, some have air in them such as the parenchyma tissues of water plants and some have oils in them such as in the peelings of citrus fruits. Lastly, the vascular tissues are the tissues responsible for the long distance transport of materials in a plant, specifically, minerals, water and sugar. Long tubes are used by plants in order to transport materials throughout its length, these are the phloem and xylem tissues. Phloem transport food in plants and are alive at functional maturity. Meanwhile, water and minerals are transported by xylem, which are dead at functional maturity. The concentric rings of a tree are actually made up of xylem, this is because the xylem becomes the wood of a tree. These show the direct relationship and structure and function in the tissues of plants.

Dermal, ground and vascular tissues make up the three general plant organs, namely, the leaves, stems and roots. The leaves mainly function in gathering light from the sun as they mainly function for photosynthesis, or the process of producing sugar from chemical reactions with the aid of the sun. The stem is a structure which functions in elongating the plant in order for it to gather as much light as possible. This is seen different height of trees in a forest, different trees and plants are able to harness light from the sun due to their different heights. Lastly, the roots functions not only in taking in water from the ground but also in anchoring the whole plant to the ground. The taller a plant is, we expect the roots to be more branching and deeper in order to support the whole tree.

Plants are also differentiated based on the structure that is normally above ground, which is the shoot system, and the structure below ground which is the root system. Another type of tissues in plants is the meristem, which is responsible for the growth of both the shoot and root system. The meristem is highly dividing tissue, thus, allowing plants to grow and replace their tissues. Those found at the tips are called apical meristems, or the shoot and root apical meristems. Meanwhile, the tissue responsible for the increased in diameter or girth of plants is the lateral meristem. Another type of meristem is found in grasses which allow them to grow their leaves even when they are cut, this is called the intercalary meristem. This is the reason why grasses are better uprooted than trimmed when taking out grasses that are weeds. But this function of the intercalary meristem allows some grasses to be ornamental as you can trim them to your desired length.

Teacher Tips:

The new terms in the lesson proper should be addressed first, either as an assignment for recitation or as another activity to lessen banking of terms. Even if the lesson calls for a lot of familiarization, dialogical discussion can occur if the students are equipped beforehand of the topic to be studied.

There is a need to focus on the different plant tissues, as this will serve as the foundation for the student's understanding of the different plant metabolism. If the plant tissues are not properly defined or discussed, there might be difficulty in the discussion afterwards. This is especially true for transpiration, root pressure and photosynthesis, wherein ground tissues and vascular tissues play a major role.

Water transport in plants

Water transport in plant is determined by the amount of water in the plants and in the environmental. This is called water potential, or the amount of water in a system. As what you have discussed before, substances move from high concentration to low concentration. This is also true for water, as water moves from high concentration (high water potential) to low water concentration (low water potential). Together with water, other substances which dissolve in water move throughout the plants through the mechanism of water potential.

Moving water up a plant

There are two ways in which water and dissolved mineral are moved throughout a plant. These are called root pressure and the transpiration-cohesion-tension mechanism of water transport. Root pressure occurs when water is built up in the roots of plants, which results in a push of water through the xylem up the stem and possibly the leaves of a plant. Usually, root pressure occurs at night when minerals are actively transported to the roots, to decrease its water potential so that water from the soil will go in. Once water has built up in the roots, the pressure will cause the upward net movement of the water and dissolved minerals. Build up water is possible because of a structure called the endodermis, which surrounds the vascular tissues, preventing backflow of water. The moisture we feel at night when we stand on a grassy soil is the result of water coming out the leaves of the grass which is caused by root pressure. Below is a picture of the summary of root pressure.

Another transport mechanism, the transpiration-cohesion-tension mechanism, harnesses the energy of the sun in order to move water from the soil to the leaves. In this mechanism, the plant or a tree functions like a straw which sips the water from the soil. As the plant uses the energy of the sun, there is no effort for the plant to use energy in moving water in this mechanism, as a result, large trees use this mechanism in transporting water and dissolved minerals. Imagine sipping on a straw, you can observe that the walls of the straw decrease its size everytime you suck into it. This is a result of the negative pressure that is built up inside the straw, this is called tension, which is a result of substances leaving the straw. The same happens in the transpiration-cohesion-tension mechanism, wherein as a result of transpiration or the evaporation of water from the leaves of plants, tension is built up in the xylem of leaves. Together with loss of water through transpiration, which results in low water potential in plants, and tension water is pulled from the lower structures (i.e. branch, stem, roots, etc.) up to the leaves. But another mechanism is needed in order for water to be pulled up, there is cohesion among water molecules which results in the pulling of the water column. Cohesion, or the bonding of like molecules, in the mechanism ensures that all water molecules are bonded to each other resulting in the creation of a water column. If the transpiration pull is stronger than cohesion, then the water column might break.

Teacher Tips:

Emphasis should be given to the difference of root pressure and transpiration-cohesion-tension mechanism, especially, root pressure's need for energy in moving water throughout the length of the plant. Also, the water that goes out of a leaf of small plant such as grasses can be explained through root pressure, as water is pushed out, not only water vapor.

In photosynthesis, there is no need to discuss the chemical reaction in detail as their background in chemistry is needed in order for this lesson to be facilitated better. As a result, their understanding of the importance of light, the light dependent and independent reactions, CO₂ and the color of the plant's are the key elements in understanding of the lesson.

The diagrams are very important in the facilitation of the discussion as it gives the students visual elements in understanding the lesson.

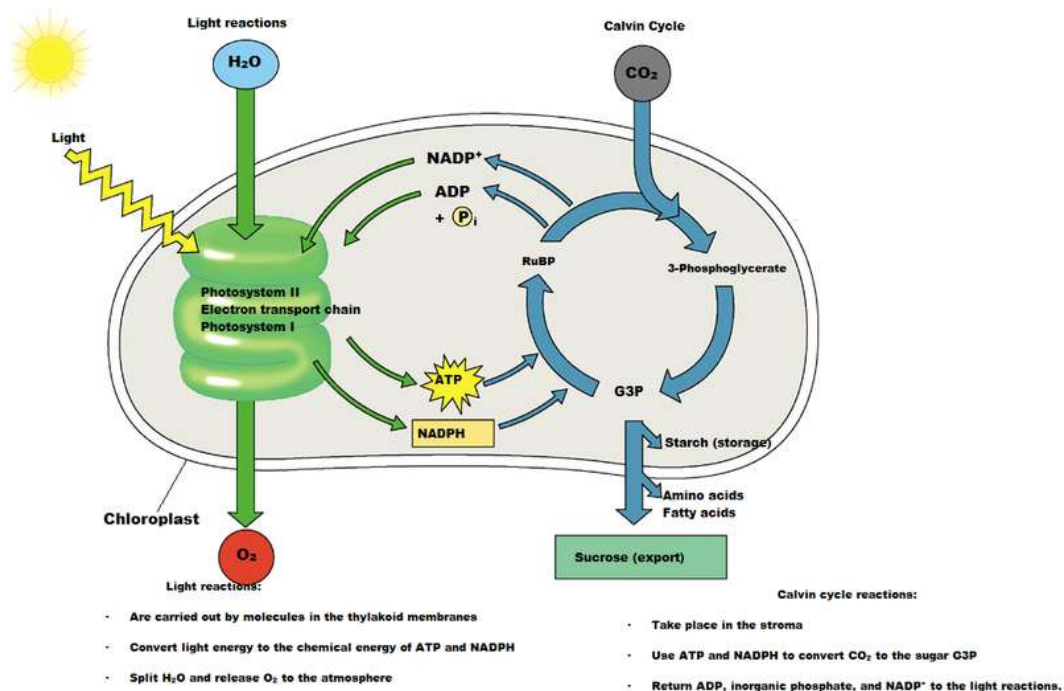
The transpiration-cohesion-tension mechanism not only functions in the movement of water and dissolved substances but also in the movement of sugars throughout the plant. If water moves only in an upward direction, sugars are moved depending on the metabolic need of the different plant organ. This is possible, as parenchyma cells are all over the plant, which are able to store sugars and released these sugars depending on the metabolizing cells. As such, as shown below, sugars move from sources of sugars and sugar sinks (metabolizing tissues/cells).

The movement of sugar in a plant is called translocation. This is explained through the pressure flow theory, wherein sugars are moved with the aid of water moving throughout the xylem and pressure built by the movement of different substances. First, sugars are moved into the sieve tube from a companion cell or nearby cells. Sieve tube is the phloem tube which allows bulk transport of phloem sap (sugars) throughout a plant. When sugar molecules are transported into a sieve tube, the water potential of that area decreases prompting the movement of water from an adjacent xylem. Because of transpiration, water is always present in the xylem. The net movement of water from xylem to phloem increases the pressure in phloem forcing the water with the dissolved sugar to move in the direction where there is less sugar. As metabolizing cells require water and sugar, they will always have low water pressure. Thus, as a result, phloem sap will move from a high water potential (source) to an area with low water potential (sink) due to the metabolism of the cells. When the phloem sap has moved to a specific area, the adjacent metabolizing cells will use the sugar from the sap. The loss of sugar will result in an increased in water potential in that area compared to the adjacent xylem, resulting in the movement of the water from the phloem and into the adjacent xylem. The illustration shows the whole process.

Photosynthesis: Converting light energy into stored energy

The sugar that is translocated all throughout the parts of a plant is a result of complex chemical reactions which involves light in one reaction that drives light-independent reaction, and ATP and other molecules which results in stored energy in the form of sugar. This process occurs in a plant's chloroplast. The chemical reaction is written this way:





Source:

<http://www.dandelion-films.com/photosynthesis-diagram-17.png>

Light is received by pigment molecules found in the chloroplasts, which drives several reactions that create ATP that can be used in the production of sugar in the Calvin Cycle. The different leaf colors, which actually is a result of different pigment molecules in the leaves, allow plants to harness the different wavelength of light energy. The Calvin Cycle or the light independent reaction of photosynthesis is the process which uses the ATP that drives the conversion of CO₂ and other molecules in the form of stored energy such as sucrose, glucose and other sugars. These sugar molecules are then stored by different plant tissues/ cells, specifically, parenchyma tissues/cells which become sugar sources for eventual metabolism of different plant tissues/cells. Once stored, the sugar molecules will then be transported via the process of translocation which was stated above.

PRACTICE AND ENRICHMENT

Based on the lesson on plant metabolism, wherein sugar is produced through the process of photosynthesis and water is transported throughout the length of a plant, discuss how vegetation impacts the environment such as in the formation of a desert or a rainforest. Relate this to the amount of water that is moved by the number of plants present in a location. Also, relate this to the type of plant in relation to the amount of water that is transported.

FOR PHOTOSYNTHESIS

The teacher can ask the class to bring colored cloths and coins or ice. Ask them to cover the object with different types of colored cloths, which differ in hue, such as white, black, blue, yellow. After covering the objects with the cloth, ask the class to touch the object and see if there is a difference in the temperature of the objects. If ice was used, ask them if they see a difference in degree in melting. Relate this to the amount of energy that a plant can gather from the sun in the process of photosynthesis.

EVALUATION (20 MINS)

The teacher can make his/her own list of questions that will allow students to practice critical thinking skills. The quiz can be administered by pairs or individually. Paired or grouped quiz allows the student to further discussed the lesson and learn from their peers. The teacher can formulate open-ended questions or multiple-choice exam from the lesson. The following are guide questions, which can help the teachers in formulating their questionnaires.

1. Differentiate the function of xylem and phloem.
2. Why is there a need for a vascular tissues, such as the xylem and phloem, in the bulk transport of materials? Is diffusion not enough?
3. In relation to the concept of plant transport, how can the story of Rizal's "Si matsing at si Pagong" be explained by your knowledge of this concept?
4. In root pressure, what will happen if there will be backflow of water in the roots? Will there be build of water pressure?
5. How will the translocation of sugar be affected if transpiration of water stops?
6. How does the variety of plant color affect the amount of stored energy a plant can produce?
7. How can you explain the death of dinosaurs in terms of photosynthesis using the theory of meteor strike which released a lot of dust into the atmosphere?
8. Why is CO₂ important in the production of sugar in photosynthesis?

REFLECTION (HOMEWORK FOR NEXT MEETING)

1. Which of the topics interest you the most? Why?
2. Which of the topics interest you the least? Why?
3. Did the activities help you understand the topic (Y/N)? Explain your answer.
4. Did you see the significance/ connection of the topic in your life?

Lesson 43: The Process of Evolution, Evidence for Evolution, and Classifying Organisms Based on Evolutionary Relationships

Content Standard

The learners demonstrate an understanding of the various pieces of evidence that support evolution and how the current system of classification is based on evolutionary relationships.

Performance Standard

The learners shall be able to describe specific pieces of evidence that support evolution such as homology, DNA/protein sequences, plate tectonics, fossil record, embryology, and artificial selection/agriculture and how the present system of classifying organisms is based on evolutionary relationships.

Learning Competencies

The learners explain how homology, DNA/protein sequences, plate tectonics, fossil record, embryology, and artificial selection/agriculture provide support for evolution (**S11/12-IVfg-25**) and explain how the present system of classifying organisms is based on evolutionary relationships (**S11/12-IVfg-27**).

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Present evidence in support of evolution
2. Design a poster tracing the evolutionary changes in a crop plant (e.g. rice or corn) that occurred through domestication
3. Explain how organisms are classified based on evolutionary relationships

LESSON OUTLINE

Introduction	Communicating Learning Objectives	10
Motivation	Admit Tickets	10
Instruction	Combination of small-group and class discussion, gallery walk, or jigsaw	90
Enrichment	Poster tracing the evolutionary changes in a crop plant	60
Evaluation	Infographic/poster creation, Exit Ticket	10

Materials

Projector, computer, student-brought poster making materials

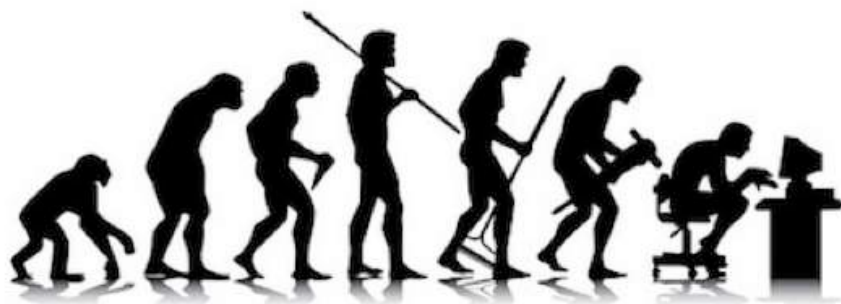
Resources

- (1) Reece, J.B., Urry, L.A., Cain, M.L., Wasserman, S.A., Minorsky, P.V., & Jackson, R.B. (2011). *Campbell Biology*, 9th ed. San Francisco, CA: Pearson Benjamin Cummings.
- (2) Online resources embedded within the document

INTRODUCTION (10 MINS)

Connect or review prior knowledge

1. For 5–7 minutes have students jot responses to these two statements and one diagram on a 3x5 note card.
 - a. Evolution is only a theory; it hasn't been proven.
 - b. Evolution has never been observed.
 - c. Keep the response options simple, e.g. "Jot down one thing you know or one question you have."



2. Collect the cards and quickly glance through them.
3. Introduce the list of important terms that learners will encounter:
 - a. Scientific theory
 - b. Evolution
 - c. Homology
 - d. Fossil record
 - e. Biogeography
 - f. DNA
 - g. Protein
 - h. Plate tectonics
 - i. Embryology
 - j. Artificial selection
 - k. Agriculture
 - l. Taxonomy
 - m. Phylogenetic tree or Tree of Life

Teacher Tips:

1. Display the objectives and terms prominently on one side of the classroom and refer to them frequently during discussion. You may place a check-mark beside a term in the wordlist after defining it so that learners have an idea of their progress. Each learner can also illustrate or define the term on a sheet of paper and this can be tacked on the area beside the word.
2. Another way of incorporating lists of important terms is to have the words placed in a blank bingo card grid. Learners can write a short definition or description of the term under the entry in the bingo card to block out a square. This may serve as the learners' reference guide/method of formative assessment.

Image source:

http://www.macleans.ca/wp-content/uploads/2013/02/5519745603_e6be133cf8.jpg

MOTIVATION (10 MINS)

Connect the lesson to a real-life problem or question

1. Look through the deck of admit tickets and choose a few typical/unique/thought-provoking cards to spark discussion. Read them out loud or call on a few individuals to share their thoughts on each of the statements above.
2. For learners that are convinced that evolution has been proven/has been observed, ask them what their beliefs are based on and what it would take to make them discard their beliefs.
3. For learners that are convinced that evolution has neither been proven nor observed, ask them what it would take to convince them otherwise.

INSTRUCTION/DELIVERY/PRACTICE (90 MINS)

Give a demonstration/lecture/simulation

DAY 1

1. Explain that you will show a short video from pbs.org that will shed light on the first statement.
2. Show the video *Evolution Primer 1: Isn't Evolution Just a Theory?* (<https://www.youtube.com/watch?v=85diEXbJBk>). Ask one volunteer to summarize what the difference is between the scientific theory and the layman's use of the word.
3. Show the video *What is the Evidence for Evolution?* (<http://statedclearly.com/videos/what-is-the-evidence-for-evolution/>) and ask learners to list as many lines of evidence as they can to support evidence for evolution.
4. Explain that the learners will work in groups to examine the evidence from various scientific resources, summarize their findings in a poster, and explain their findings to their classmates in a gallery walk tomorrow.
5. Group students according to the following teams and give them the readings/links:
 - a. Direct evidence (<http://blogs.scientificamerican.com/science-sushi/evolution-watching-speciation-occur-observations/>)
 - b. Homology (http://evolution.berkeley.edu/evolibrary/article/0_0_0/lines_04 and http://evolution.berkeley.edu/evolibrary/article/0_0_0/lines_05 and http://evolution.berkeley.edu/evolibrary/article/0_0_0/lines_06)
 - c. Fossil record (<http://humanorigins.si.edu/node/559>, http://evolution.berkeley.edu/evolibrary/article/0_0_0/history_17, http://evolution.berkeley.edu/evolibrary/article/0_0_0/lines_02 and http://evolution.berkeley.edu/evolibrary/article/0_0_0/lines_03 and http://evolution.berkeley.edu/evolibrary/article/0_0_0/lines_10)

Teacher Tips:

1. You may write the task on the board so that learners can focus on it while watching the video.
2. If your class does not have access to the internet, print the sites and distribute one copy per group. Alternatively, you may also use this resource (<http://www.nap.edu/read/6024/chapter/4>) for groups b to f.
3. If your class has access to computers, they may opt to create one presentation slide summarizing their important points instead of a physical poster and present these to their classmates on computer monitors or tablets instead.

- d. DNA/protein sequences (<http://humanorigins.si.edu/node/563>, http://evolution.berkeley.edu/evolibrary/article/0_0_0/lines_08 and http://evolution.berkeley.edu/evolibrary/article/0_0_0/history_26)
 - e. Plate tectonics and biogeography (http://evolution.berkeley.edu/evolibrary/article/0_0_0/history_16, http://evolution.berkeley.edu/evolibrary/article/0_0_0/lines_09 and http://evolution.berkeley.edu/evolibrary/article/0_0_0/lines_11)
 - f. Embryology (http://evolution.berkeley.edu/evolibrary/article/0_0_0/history_15 and http://evolution.berkeley.edu/evolibrary/article/0_0_0/lines_07)
 - g. Artificial selection/agriculture (http://evolution.berkeley.edu/evolibrary/article/0_0_0/lines_13, http://evolution.berkeley.edu/evolibrary/article/0_0_0/evo_30, and <http://blogs.scientificamerican.com/science-sushi/observations-evolution-the-curious-case-of-dogs/>)
6. They should use the period to discuss the assigned readings and prepare a poster that they should be able to discuss with the rest of the class. Some sample guide questions follow:
- a. How have discoveries/advances in your assigned field supported evolution?
 - b. How convincing is the evidence from your assigned field in supporting evolution?

Teacher Tip:

Limit the time spent discussing each poster to 5-7 minutes per group.

DAY 2

1. Post the group output around the room or in the hallway.
2. Regroup participants so each new group has at least one member from the previously established groups.
3. Give specific directions at which poster each group will start and what the rotation will look like.
4. The speaker at each poster is the person(s) who participated in the creation of the poster.
5. When all groups have visited each poster, facilitate a class discussion focusing on the key terms for each field, clear up any misconceptions, and provide constructive criticism for the different groups. Stress that the presence of multiple lines of evidence from different fields serve to strengthen support for evolution.

DAY 3

1. Explain that you will now be discussing an important application of evolution in systematics. The vast diversity of life should be classified into meaningful, not arbitrary, groups. The present system of classification is based on the evolutionary history of life. This allows it to reflect the evolutionary relationships between different groups of organisms and predict properties of newly-discovered or data-deficient organisms. Classification is part of the broad field of phylogenetic systematics, the study of the relationships between different groups of organisms. The construction of phylogenetic

trees from molecular data is one of the modern tools by which this may be accomplished.

2. Project the interactive slide deck *Creating Phylogenetic Trees from DNA Sequences* (http://media.hhmi.org/biointeractive/click/Phylogenetic_Trees/) and go through it with the class.
3. Learners should answer a worksheet with the following questions while going through the slide deck:
 - a. How are DNA sequences used to determine evolutionary relationships?
 - b. How are phylogenetic trees created from DNA sequences?
 - c. Sketch a simple phylogenetic tree and interpret the information that it contains.
 - d. How can this information be used to classify organisms?
4. Discuss the possible answers to the worksheet and clarify misconceptions.

ENRICHMENT (60 MINS)

Design a poster tracing the evolutionary changes in a crop plant (e.g. rice or corn) that occurred through domestication.

EVALUATION (10 MINS)

DAY 1 - Performance Task

1. Posters for the gallery walk
2. Individual oral presentations by the students

DAY 2 - Written Task (Exit Tickets) (10 MINS)

1. Students revisit their admit tickets. On the back of their tickets, they should write what they've learned about the following statements/diagram from the gallery walk/poster making and present concrete examples of evidence from different fields.
2. Collect the cards and assess for accuracy and comprehensiveness of answers.
 - a. Evolution is only a theory; it hasn't been proven.
 - b. Evolution has never been observed.

Teacher Tip:

Tell the learners that they will be making models next meeting and have them bring recyclable materials that they can use for this activity.

Lesson 44: Evolution

Content Standard

The learners demonstrate an understanding of the origin and extinction of species.

Performance Standard

The learners shall be able to design a poster tracing the evolutionary changes in plants or animals that occurred through domestication

Learning Competency

The learners explain how populations of organisms have changed and continue to change over time showing patterns of descent with modification from common ancestors to produce the organismal diversity observed today.

(S11/12LT-IVfg-26)

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Create a concept map of the historical developments of the Theory of Evolution
2. Differentiate Lamarckian Evolution and Darwinian Evolution through illustrations or models
3. Understand Darwin's Theory of Evolution
4. Clarify Misconceptions about the Theory of Evolution

LESSON OUTLINE

Introduction	Before and After	5
Motivation	A. Spotlight: Philippine biodiversity B. Do you know me?	15
Instruction	A. Concept Map Activity B. Lesson Proper	180
Practice	Natural Selection Activity	40
Enrichment	A. Before and After B. Clarifying Misconceptions	40
Evaluation	Pop-Evo (Popularizing Evolution)	20

Materials

Laboratory equipment, raw materials, school supplies

Resources

(1) Reece JB, Urry LA, Cain ML. 2010. Campbell Biology 10th. San Francisco(CA):Pearson Benjamin Cummings; 2010. p.265, pp. 462-470

INTRODUCTION (5 MINS)

1. Start the class with the Before and After activity.
2. Ask your students to write their thoughts about evolution. Encourage them to write any of their thoughts, make sure that you'd be clear with this activity that it is not graded and there will be no wrong answers. Pick 2-3 students to share their thoughts in front of the class. After, collect all papers and seal it in a brown envelope.
3. Follow up the activity by formally opening the topic with the learning competency:
 - a. Explain how populations of organisms have changed and continue to change over time showing patterns of descent with modification from common ancestors to produce the organismal diversity observed today.
 - b. Remind the students the evolution is one of the characteristics of life and unifying theme in the study of Biology

Teacher Tips:

The purpose of having the papers sealed inside a brown envelope because at the end of the discussion you will get their thoughts and you will distributed the "before" conception about evolution then ask them to compare it with their "after" thoughts about the discussion of the theory of evolution.

Before the start of the topic. It is highly suggested to give an assignment about the historical development of the theory of evolution. The students must have an independent research on the ff scientists:

- Carolous Linnaeus
- Thomas Malthus
- Jean Baptiste de Lamarck
- Georges Cuvier
- James Hutton
- Charles Lyell
- Gregor Mendel
- Charles Darwin
- Alfred Russel Wallace
- Hugo de Vries
- Carl Correns
- Erich Von Tschermak
- Rosalind Franklin
- James Watson
- Francis Crick

Ask your students to know their direct or indirect contribution to the Theory of evolution. Make sure to emphasize that it is not the focus of the activity to memorize dates, but at least to have an idea when the scientist exist or done his/her significant work.

MOTIVATION (15 MINS)

- A. **Spotlight: Philippine Biodiversity.** Show a video about Philippine Biodiversity. Then give your students 3-5 minutes to relate the video shown to evolution. After, define evolution and state that evolution explain the diversity of life and not its origin (how life emerged on earth)

Evolution

- Descent with modification; the idea that living species are descendants of ancestral species that were different from the present day ones (Campbell Biology 10th Edition definition)
 - Change in the genetic composition of a population from generation to generation. (Campbell Biology definition)
 - Gradual change over time
- B. **Do you know me?** Prepare the set of pictures of scientists mentioned in the teacher tip column. Students must be able to identify the names of the scientists. You may give their significant contributions (directly or indirectly) as you flash their picture. If an LCD projector is not available, the teacher can prepare printed pictures of the scientists and flash it in front of the class or have each photo posted inside the classroom and allow the students to move around to identify.

Teacher Tips:

Use the Haribon videos about Philippines' Biodiversity. You may choose from a number of Biodiversity videos of Haribon. Make sure that you also consider the time allotted for the motivation.

Ask your class if they can explain "descent with modification" or "idea of common descent". And why it is defined as change in genetic composition of a population from generations to generations? If your students cannot explain the definitions, challenge them to know the explanation and listen to your discussion.

This activity will help you motivate your students to know the contributions of the scientists in the development of the theory of evolution. This will also give the students a clearer picture that Darwin is not the sole proponent of the theory of evolution. Moreover, it will show the students what Darwin lacks (idea) during his time.

INSTRUCTION/DELIVERY (180 MINS)

Activity (10 minutes for the class' concept map and 10-15 minutes for the discussion)

Concept Map on the Historical Developments of Evolutionary thoughts. The whole class will do the concept map. Allow your students to use their homework about the scientist in creating the concept map. Write Charles Darwin's name on the board to start the activity (as the central concept). Encourage the students to write their processed research on the board. After the class is done with the map, discuss the concept map.

Some info about the scientist:

1. Carolous Linnaeus
 - a. Father of taxonomy (differentiate classical taxonomy and modern taxonomy)
 - b. Started the binomial system of nomenclature

2. Thomas Malthus
 - a. Believed that populations grow geometrically while resources slowly increase or not at all, leading to competition
3. Jean Baptiste de Lamarck
 - a. First to propose about the theory of evolution: Theory of inheritance of acquired traits and Theory of use and disuse
 - b. Physiological needs drive Lamarckian evolution
 - c. Defined evolution as process of increasing complexity
 - d. No extinction of species. Species disappeared because they just evolved into different species.
 - e. Organisms adapt to evolve
4. Georges Cuvier
 - a. Established extinction through fossils
 - b. Believed that the earth was immensely old
 - c. Catastrophes caused that each one wiped out a number of species
 - d. Didn't believe organic evolution because of the mummified cats and ibises
5. James Hutton
 - a. Proposed theory of gradualism (Slow subtle processes could cause substantial change over time)
 - b. Great age of the earth
6. Charles Lyell
 - a. Proposed the theory of uniformitarianism (natural agents now at work on and within the Earth have operated with general uniformity through immensely long periods of time)
7. Gregor Mendel
 - a. Studied garden peas
 - b. Responsible for the: Law of segregation (two alleles for each gene separate during gamete formation) and Law of Independent Assortment (alleles of genes on nonhomologous chromosomes assort independently during gamete formation)
8. Charles Darwin
 - a. Explained evolution through: Natural Selection, Idea of Common Descent, Idea of Gradualism, Idea of Multiplication of species
 - b. Organisms evolve to adapt

Teacher Tips:

In this activity, the teacher must be able to discuss the significance of the contributions of the scientists in the development of the theory of evolution. Must also pinpoint the field of scientists to show that different disciplines of science can be considered together to support or disprove theories. It is highly suggested the teacher establish the following:

- Importance of Binomial system of nomenclature (the teacher might as well teach the students on how to write scientific names correctly)
- Significance of Malthusian essay on natural selection
- The importance of Lamarck's theory of evolution and why it was disproved
- The importance of fossils in evolution. And Cuvier's contradicting idea of fossils and evolution
- Importance of Hutton's and Lyell's theories
- Missing ingredient in Darwin theory of Evolution through Mendel's works
- What drive Darwin to think that evolution happens
- Who is Alfred Wallace? Show how science work and how they collaborate
- Importance of rediscovering Mendel's work
- Issues and challenges faced by women in the olden times
- Issue on Crick and Watson stealing Franklin's work
- Importance of DNA in evolution

9. Alfred Russel Wallace
 - a. Had a correspondence with Darwin regarding the theory of evolution by mean of Natural selection
 - b. Realized that species evolved because fittest individuals survived and reproduced passing their advantageous characters.
10. Hugo de Vries
 - a. Rediscovered Mendel's work
 - b. Thought of theory of mutation but his idea of mutation before has nothing to do with the real mutations
11. Carl Correns
 - a. Rediscovered Mendel's work
 - b. Worked on the Behavior of the Progeny of Racial Hybrids
12. Erich Von Tschermak
 - a. Rediscovered Mendel's work
 - b. Applied mendial laws to artificial selection to improve crop yield
13. Rosalind Franklin
 - a. One of the few women during their time to be recognized for her contribution in the scientific community.
 - b. Worked on the x-ray diffraction image of the DNA. X-ray crystallography picture of the DNA that time were not pictures of molecules. The spots were produced by diffracted x-rays from the fibers of a purified DNA.
 - c. She also concluded that the sugar-phosphate backbones were outside the DNA molecule (contrary to Crick and Watson's claim)
 - d. Died at the age of 38 (1958) so she was ineligible for the Nobel Prize.
14. James Watson and Francis Crick
 - a. Discovered that the DNA is a double stranded helix, from Rosalind Franklin's works

Lamarckian vs. Darwinian Evolution: Comparing theories on Evolution

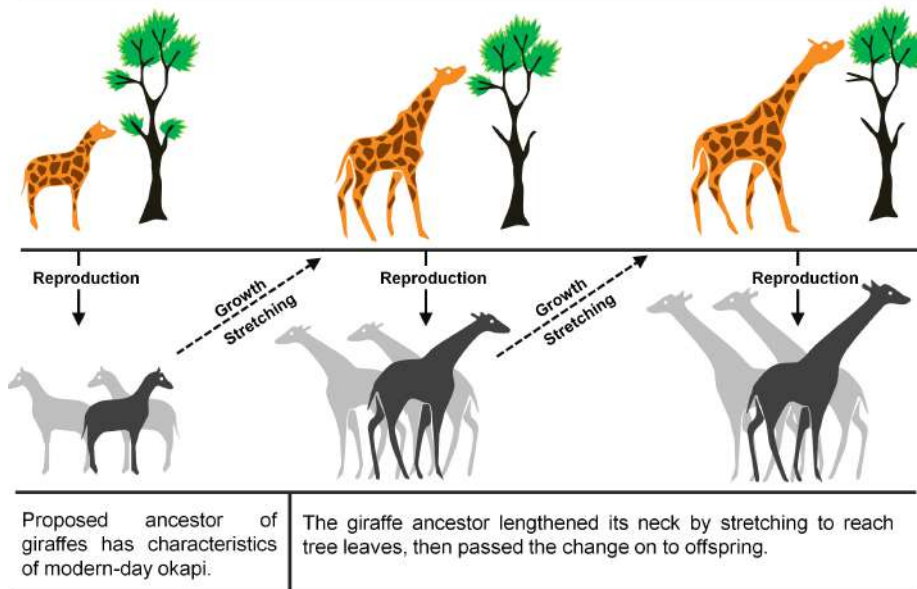
Schools of Thought	Lamarckian	Darwinian
Central idea	Physiological needs drives organisms to evolve; to become more complex	Natural selection: nature selects which organisms will survive and reproduce
Explanation on how adaptations of organisms arise	Theory of inheritance of Acquired traits; and Theory of Use and Disuse	Descent with Modification by natural selection; survival of the fittest
Smallest unit that can evolve	Individual species	Populations
Do variations initially exist in populations?	No, variations are caused by inheriting acquired traits	Yes, important requirement for evolution
Common idea	Environment as an important factor for evolution	Environment as an important factor for evolution
Does extinction happen?	No, organisms just evolved into another species	Yes, organisms that do not possess adaptations (favorable traits) for a specific environment go extinct.
Missing ingredient	Variations in population, acquired traits are not passed to the next generation	Raw material for evolution-mutation and how traits are passed from parents to offspring (Genetics) since Darwin observed offspring to be resembling parents but not identical to them

After the comparison of Lamarckian and Darwinian evolution. Test the students if they understand these two different thoughts on evolution by doing an illustration on how organisms evolve. Your students may use different animals of their interest.

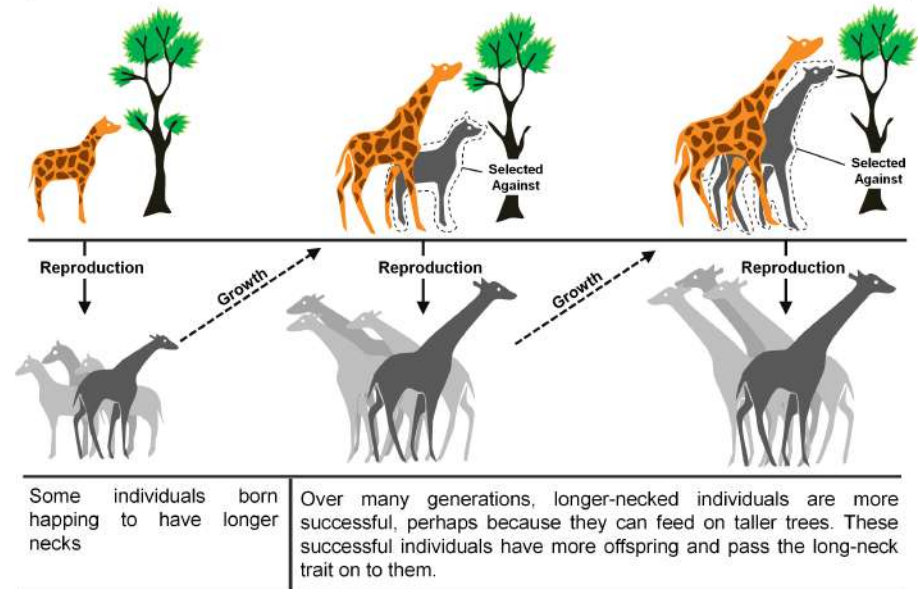
Challenge to the teacher. Try to answer the following questions:

1. What's missing in the initial Lamarckian illustration?
2. How did the giraffes grow their necks and legs?
3. Explain the driving force of evolution of the giraffes.
4. Disprove Lamarck's mechanism of evolution.
5. Relate Lamarckian evolution with Pokemon evolution (Pokemon is a Japanese cartoon series)
6. What are the criteria needed for Darwinian evolution to take place?
7. Which factor dictates the survival of the species?
8. What do we mean by adaptations in the context of evolution?
9. Define the verb "adapt". Does survival in a particular environment through coping is synonymous with evolution? Why or why not.
10. Why did some giraffes die?
11. Which factor of evolution determines the fittest organisms?
12. What did Darwin observe with the finches of Galapagos?
13. If Darwin wasn't able to observe the finches of Galapagos would you think he would think that evolution happens?

Lamarck's Theory: Variation is Acquired



Darwin's Theory: Variation is Inherited



Voyage of the Beagle

1. Primary mission of the voyage id to chart poorly known stretches of South America coastline
2. Darwin observed and collected thousands of plants and animals
3. Noted organisms special features that enabled it to survive diverse environments
4. Associated species of plants and animals in South America's temperate and tropical regions as more closely related species than species of the temperate regions of Europe
5. Fossils found in South America resemble living species in that same region
6. Read Lyell's Principle of Geology
7. Saw fossils of aquatic organisms in the Andes (mountain region), and accounted its presence through many earthquakes that may have happened. These observations affirmed his learning from Lyell.
8. The voyage reached Galapagos where he observed finches. There were finches unique to the island while there were others that resembled the mainland species. This helped him hypothesize that the Galapagos was colonized by species from the mainland South America then diversified giving rise to different species (on different islands).

Darwin's focus on Adaptation

1. Adaptation- inherited characteristics of organisms that enhance their survival and reproduction in specific environments. Observed in the Galapagos finches.
2. The difference in beak types and behaviors are adapted to the specific food in home islands
3. Natural selection caused these adaptations to arise. Natural selection explains the difference in survival of individual since some individuals of the same species have inherited traits (adaptations) that allow the organism to survive and reproduce in a particular environment.
4. Nature selects organisms with high fitness
5. Darwin thought of the idea of descent with modification, which was caused by natural selection. Though at that time he was not quite confident of his idea, until Alfred Wallace sent him his manuscript (worked in the Malayan Archipelago) that contains Wallace's hypothesis of natural selection identical to Darwin's. And asked Darwin if he can ask Lyell if it has merit for publication.
6. Lyell presented Wallace's paper with Darwin's unpublished essay to the Linnaean Society of London. The following year Darwin published his book: On the Origin of Species by Means of Natural Selection

The Origin of Species

1. Darwin's observation on nature
2. The unity of life (descent of all organisms from ancestors)
3. Diversity of life (caused by descent with modification)
4. Match between organisms and their environment (from descent with modification by natural selection)
5. Darwin didn't use the word evolution in his book (though the final word in the book is EVOLVED), but instead he used the term "descent with modification"
6. Viewed life history as a tree as compared to Lamarck's ladder view on species

Teacher Tip:

In order to show that Darwin did write to Lyell to let him know Wallace's work. You may read the ff. in class:

Darwin complied, writing to Lyell:
"Your words have come true with a vengeance. . . I never saw a more striking coincidence . . . so all my originality, whatever it may amount to, will be smashed."

It is also important to take note in class that Wallace had his manuscript published first, but with his admiration to Darwin's extensive explanation of natural selection, it was not an issue to him to consider Darwin as the main originator of the idea of natural selection

Artificial Selection vs. Natural Selection

1. Artificial selection- process of selecting and breeding of animals and plants over many generations to achieve the modifications desired by human beings..
2. Caused the production of individuals used for crops, livestock, pets that resemble wild ancestors
3. Instead of nature serving as the selecting factor, its humans that select which organisms will be used for breeding depending on to the traits they want to improve.
4. Can take effect faster than natural selection, though follows the same principle as natural selection where favorable traits will be more frequent in a population while less favorable traits will diminish.

Natural Selection

1. Differential in rates of survival is dependent on individual's heritable traits suited in the environment
2. An organisms compatibility with its surrounding is increased by natural selection over time.
3. A change in environment (or movement of individuals to new environment) may cause a species to give rise to a new species depending on the traits that will be favored by the new environment.

PRACTICE (40 MINS)

Natural Selection in Action (revised activity from PSHS MC's laboratory experiment on evolution). Divide the class in into 10 groups of 3 students (assuming that the class size is 30). Prepare 600 pieces of toothpicks. Dye the toothpicks: 200 green, 200 red and 200 brown color (this will depend on the sites that you will use in your school- green for the grassland, red for the waxed floor and brown for the soil). Look for different picking instruments such as: tongs, forceps, test tube holder, chopsticks, kitchen tongs that will be used as beaks in the experiment. The pickers will also be given containers where they will be placing the toothpicks.

Teacher Tip:

The toothpicks are 200 per color, this is so to ensure that there is a buffer of toothpicks in case of unsuccessful retrieval or damaged toothpicks. ONLY 100 toothpicks per color will be used every round, making the total toothpicks 300 pieces.

Procedure:

1. Assign roles to each member of the group: 1 recorder, 1 picker/ bird, 1 clean up crew. After assigning, have a representative of the group to choose their tool for the activity. Make sure that you do not disclose what the tool represents in the experiment. Assign a timer in the class to make sure that each round in the activity is 30 seconds.
2. Make a 4x4m plot on 3 different sites (grassy area, classroom area and soil area). You may have this done by the clean up crew representatives of the 10 groups. While you are discussing the mechanics of the activity.

3. RULES

- a. The pickers are not allowed to look at the recorders when they scatter the toothpicks randomly in the plot.
- b. The recorder will make sure that the toothpicks are randomly scattered and is not allowed to coach the picker in the activity.
- c. The clean up crew works every after round by retrieving toothpicks that are left in the plot. He/ she will also make sure that every round each color has 100 individuals, making the total per round 300.
- d. Every after round, the picker will count the number of toothpicks picked while the recorder makes sure that it is right. The recorder records the data of the group.
- e. Once the data were recorded and the toothpicks are retrieved. The pickers will then again close their eyes or will face opposite the plot in order not to see the distribution of the toothpicks by the recorder.
- f. The pickers are NOT ALLOWED TO PICK TOOTHPICKS MORE THAN ONE AT A TIME.

4. Activity proper

- a. There will be 2 rounds per site. Only the top 5 groups will be able to proceed the next round, in cases of tie- the teacher will make sure that there are only 5 groups to proceed but if tied groups will make 6 groups to proceed, its okay.
- b. Scatter the toothpicks (will be done by the recorders) while the pickers are not facing the plot or their eyes closed. The recorders will signal the timer/teacher that the set up is ready. The timer/ teacher will signal the start of the activity. As quickly as possible (or efficient as possible) the picker will be getting the toothpicks and will place it in their containers. They may compete with other groups but they cannot get the toothpicks in other group's container. There should be no pushing or distraction of other pickers. The timer must signal the groups to stop after 30 seconds.
- c. After round 1, the picker will count the toothpicks per color and will be verified by the recorder. During this time the clean up crew will retrieve the toothpicks in the plot and will make sure that there will be 100 per color (300 total) for the following round.
- d. Top 5 teams will qualify round two. Repeat the procedure. Then record the data. Once done, proceed to the next plot.

Toothpick color	Round 1	Percentage	Round 2	Percentage
red				
green				
brown				
Total				

Group Percentage per color = (total per color/ total of all toothpicks used per round) x 100%

Group Percentage total toothpicks+ (total toothpicks obtained/total of all toothpicks used per round) x 100%

You have to make sure that the class will collate the CLASS data. Challenge them to make a table for the class that will show the toothpicks obtained per color per beak type used.

At the end of activity the students must answer the following:

1. Draw and describe (material it is made of, use) the beak type your group chose.
2. Explain the technique used by your group in the activity. Have you also observed other groups' techniques?
3. Which tool used in the activity is the most successful to pick the most number of toothpicks? Why?
4. Construct a graph from the table you made. Explain the graph/s.
5. Relate natural selection in the activity. State the representation of the materials used in the activity to natural selection. And how does the activity show it.
6. Which toothpick is the fittest? Explain your answer.
7. What are the factors needed for natural selection to take place? Was it exhibited in the activity? Explain.
8. Do you think the activity helped you in understanding Darwin's theory of evolution? Why?

ENRICHMENT (40 MINS)

Clarifying Misconceptions (use the Berkeley material in this activity)

Group student into 6 groups of 5 students (class size 30). Prior to the activity the students must worked on their homework and read about the misconceptions about the theory of evolution. It will also be helpful if you also assigned students to look for explanations that will clarify misconceptions. In order to facilitate this, it would be better if you flash (one at a time) in class the misconceptions that will be discussed for 5 minutes each.

Make sure that you sum up the SGD and be able to end the discussion with the idea that Darwin's theory of evolution never claimed that we directly came from apes, instead we share a common ancestor. That organism evolved because of natural selections (over many generations; organisms, **as population**, evolved to adapt). Evolution explains the unity (common ancestry) and diversity of life (descent with modification) not how life emerged on earth.

EVALUATION (20 MINS)

1. **Before and After.** The "after activity", at the end of the topic you will be asking your students to define evolution and write their thoughts on evolution. Open the sealed folder of their before thoughts on evolution and give it back to the owners. Let them compare their views on evolution. Collect it again, to compare your students before and after thoughts. The teacher can keep track this activity and have it yearly, to see if there is a trend in the perception of students on evolution.
2. **Pop- Evo (Popularizing evolution).** Divide the class into 5 groups. Ask them to make a proposal about the topic in evolution and the output that they plan to have. The output can be in the form of video, poster, info-graph, diorama, story books, comics or anything that they can think of. Give the groups enough time to finish the output. You may have an exhibit of the outputs, to raise the science literacy of the school (students, teachers and admin workers). (Ex Poster explaining artificial selection, popularization of scientists that helped in the development of the theory of evolution etc.)

How to grade the output (suggested grading scheme)

Proposal 20%

- Introduction of the chosen topic 5%
- Rationale (why did the group chose the topic) 5%
- Plan of action (division of tasks and how they will promote their project) 5%
- Planned output (description of the output with draft, storyboard etc) 5%

Preliminary output 15%

- Draft of your output. Encourage the students to submit the best state of their output so there will be just minor revision to be made. Suggestion/revisions will be suggested by the teacher and also by the class (if possible) to improve the output.

Revisions 10%

- Suggested ways on how to improve the drafts/first submissions. The group must be able to do the necessary changes that are needed to make the outputs better.

Execution 10%

- Progress report that will be done by the group in reference to the target dates they set
- Includes the manner of promotion and posting of the actual outputs

Group rating 10%

- Peer review of the group members with each other. Here is a sample rubrics from the university of texas ([insert link here](#))

Class rating 5%

- The class will also rate other groups' output. (Insert sample rubric here)

Final Output: 30%

- Scientific (biology concept covered) 10%
- Creative value (appearance, format) 10%
- Impact as a tool for increasing science literacy 10%

Lesson 45: Interaction and Interdependence

Content Standard

The learners demonstrate an understanding of the basic principles of ecology.

Performance Standard

The learners shall be able to prepare an action plan containing mitigation measures to address current environmental concerns and challenges in the community.

Learning Competency

The learners describe the principles of ecology **(S11/12LT-IVhj-28)**

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Understand the basic concepts of ecology (Trophic Levels and Energy Flow)
2. Illustrate the following cycles: water, carbon, nutrient (nitrates, phosphates) and relate these to water conservation, global warming and climate change, and nutrient/organic pollution.

LESSON OUTLINE

Introduction	Communicate Learning Objectives	5
Motivation	Ask a question	10
Instruction	Lecture, Group Discussion	90
Practice	Classroom Exercises	40
Enrichment	Video	20
Evaluation	Submission of a reaction paper	10

Materials

Laboratory equipment needed, raw materials, school supplies

Resources

- (1) Ecological Principles – <http://www.ecoliteracy.org/essays/ecological-principles> and https://www.soinc.org/sites/default/files/uploaded_files/GG_HANDOUT-P1-ECOPRINCIPLES.pdf
- (2) Water Cycle – <http://water.usgs.gov/edu/watercyclesummary.html>; https://www.fcwa.org/story_of_water/html/hydrocycle.htm
- (3) Nitrogen and Phosphorous Pollution – <http://www.cbf.org/about-the-bay/issues/dead-zones/nitrogen-phosphorus>

INTRODUCTION (5 MINS)

1. Introduce the learning outcomes.
 - a. Describe the principles of the ecology

TOPIC OUTLINE:

- a. Introduction to Ecology
- b. Levels of Organization of Living Things (Atom to Biosphere)
- c. Energy Flow
- d. Food web, food chain, nutritional relationships
- e. Trophic Levels
- f. Water Cycle
- g. Carbon Cycle
- h. Nitrogen Cycle
- i. Phosphorous Cycle

MOTIVATION (10 MINS)

1. Ask a question that is relevant to ecology. Example:
 - a. What is ecology and what is its importance to your life?
 - b. How much water do you consume in a day? Relate to water conservation;
 - c. Ask if the students know the importance of planting trees.

Teacher Tip:

Do not use "Principles of the Ecosystem". Before the topic, assign the students to compute their water consumption (include toilet, bathing, laundry etc activities).

Teacher Tip:

Formulate questions that are applicable to your school - you can include garbage, weather, flooding

INSTRUCTION/DELIVERY (90 MINS)

ECOLOGY DEFINED

1. Define ecology: study of the interaction between biotic and abiotic factors of the environment.
2. Ask students to identify biotic and abiotic factors in an ecosystem using a specific example (a place in the campus that students are familiar with). Ask them what species, populations and communities are present.

Teacher Tip:

FISH POND - Abiotic factors: water, soil, temperature, stones; Biotic factors: populations of tilapia, guppies, *Hydrilla*, toads, etc.

ECOSYSTEMS

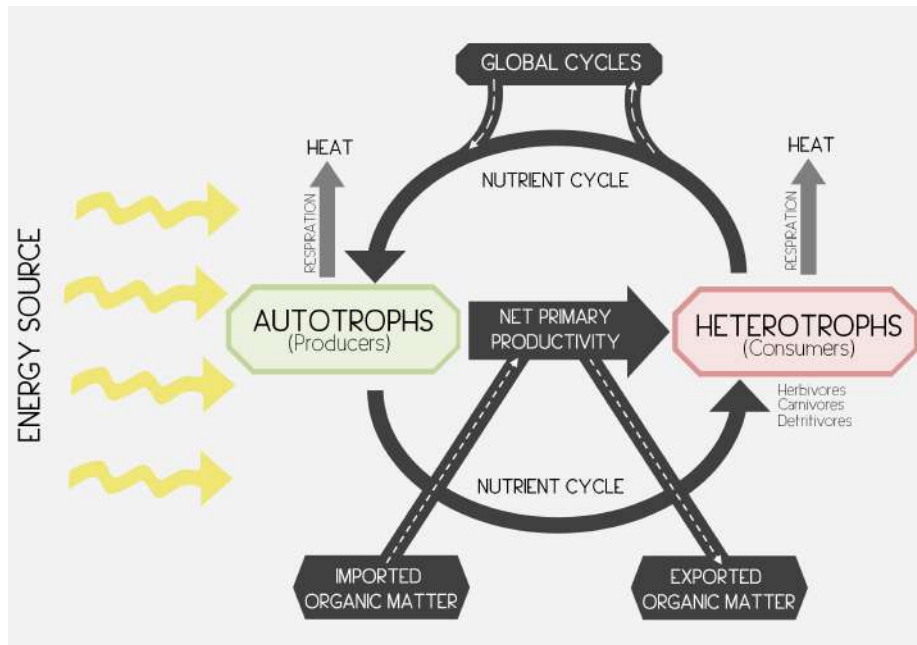
1. The ecosystem is the structural and functional unit that is studied in ecology
2. They involve important interactions between biotic and abiotic factors
3. An ecosystem can support itself and is stable (not much change) when three conditions are met:
 - a. There must be a constant supply of energy (the sun is this source for all life on earth)
 - b. There must be living organisms that can convert the energy into organic compounds (plants--autotrophs--photosynthesis)
 - c. There must be a recycling of materials between organisms and the environment.

Source

<http://www.goldiesroom.org/Note%20Packets/22%20Ecology/00%20Ecology--WHOLE.htm>

Source

<http://www.goldiesroom.org/Note%20Packets/22%20Ecology/00%20Ecology--WHOLE.htm>



Levels of Organization

1. **Population** - includes all the members of a species in a given area. Example: All toads (including tadpoles) in a pond is a population.
2. **Community** - All populations in a given area. Example: Toads, tilapia, guppies (fish), water lilies, *Hydrilla*, and other populations in the pond.
3. **Ecosystem** - composed of the living (biotic) community and the nonliving (abiotic) physical environment functioning together is an ecosystem
4. **Biosphere** - is the portion of the earth in which LIFE exists and is made up of many complex ecosystems. All ecosystems together make up the biosphere.

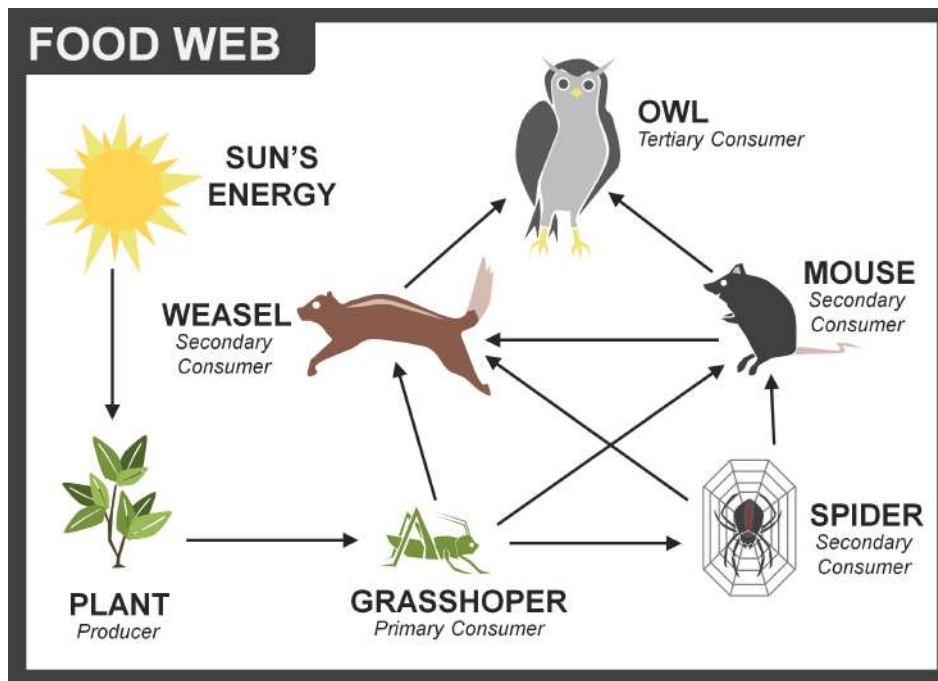
With a few exceptions, all ecosystems depend on solar energy as a primary energy source.

This energy (called Primary Productivity) is the result of energy captured by producers. Some of this energy is lost when producers, such as plants, use energy for respiration. Only a portion of the energy captured by producers is passed on to consumers. Consumers also lose energy due to respiration.

Note that the energy flow through an ecosystem is one way; it is not recycled. All the energy taken in by producers is ultimately lost as heat through respiration. Autotrophs must continue to capture the sun's energy for ecosystems to persist.

Most energy is lost as heat because of the **LAWS OF THERMODYNAMICS**

- 1st Law of Thermodynamics – Law of Conservation of Energy; “Energy cannot be created or destroyed, they are transformed from one form to another”
- 2nd Law of Thermodynamics – Law of Entropy; the entropy of the world only increases and never decreases – so during transformations, energy in form of heat is lost.
- Teacher Tip – Leave the 3rd Law to Physics



Teacher Tips

- Autotroph:** (“auto” – self; “trophe” nutrition); Are organisms synthesize their own food.
- Heterotroph:** (“hetero” – other; “trophe” nutrition); cannot manufacture its own food and instead obtains its food and energy by taking in organic substances, usually plant or animal matter.

Source

http://www.mhhe.com/biosci/esp/2001_gbio/folder_structure/ec/m3/s2/

Misconception

- All ecosystems depend on solar energy. Ecosystems in the deep sea (like geothermal vents and cold seeps) where light cannot penetrate do not use solar energy.
- Respiration – also called metabolism is the process where the cell makes ATP (Adenosine Triphosphate) which is the form of energy usually used in biological activities.
- Entropy – Example is changes in one's bedroom through time if there is no input of energy (cleaning or fixing).
- from <https://www.boundless.com/chemistry/textbooks/boundless-chemistry-textbook/thermodynamics-17/the-laws-of-thermodynamics-123/the-three-laws-of-thermodynamics-496-3601/>
- Food Chain** - shows the pathway of energy from one organism to the next in a direct line of organisms.
- Food Web** - shows the interactions and interconnections among the different food chains of a community. It shows that most organisms eat, and are eaten, by more than one species.

NUTRITIONAL RELATIONSHIPS

AUTOTROPHS or PRODUCERS – are organisms that can synthesize organic molecules from inorganic molecules; also called **producers**; can be either photosynthetic or chemosynthetic

HETEROTROPHS – are organisms that cannot manufacture organic molecules. They are the “consumers”; there are 5 types of heterotrophs:

1. Herbivores – Organisms that eat only producers (plants); also called a primary or first-level consumer; Examples are the ruminants – cows, goats, carabaws.
2. Carnivores – Organisms that eat only other animals; can be a secondary/tertiary/quarternary consumer; Examples are members of Order Carnivora – Dogs, cats, bears, wolves.
3. Omnivores –Organisms that eat both plant and animal material; Example – Humans
4. Scavengers– Organisms that eat only other animals after they are already killed; Example - vultures, hyenas

DECOMPOSERS – They 'recycle' dead organisms and waste (feces) into non-living elements by reducing these feces into chemicals such as nitrogen and carbon. Those chemicals become part of the soil and those nutrients can then be used by living plants and the animals that consume them.

1. Saprophytes - The main groups of decomposer organisms are bacteria and fungi that cause decay at a microscopic level. Saprophytes cause decay by releasing enzymes onto the dead animal or plant, breaking down complex compounds into simple soluble ones that can be absorbed by decomposers.
2. Detritivores - Other larger organisms, called detritivores, help speed up decay by feeding on detritus. Detritus is dead and decaying material and detriivores break it down into smaller pieces, so increasing the surface area for the bacteria and fungi. Detritivores include earthworms that help break down dead leaves, maggots that feed on animal tissue, woodlice that break down wood

SPECIAL NUTRITIONAL RELATIONSHIPS - SYMBIOSIS and PARASITISM

SYMBIOSIS - an interaction among different species in an ecosystem that where they live in a close association with each other where at least one member of the association benefits (gains) by the association

1. **Mutualism** - a symbiotic relationship in which BOTH organisms benefit from the association. Example: Termites and its intestinal parasite; giant clams and its symbiotic algae; nitrogen fixing bacteria that live in nodes on the roots of legumes; shrimp and goby (fish).

Misconception

- Dogs are CARNIVORES that have adapted the ability to an omnivore diet due to its association with man.
- <http://www.vetstreet.com/our-pet-experts/are-dogs-carnivores-heres-what-new-research-says>
- <http://www.dogfoodadvisor.com/canine-nutrition/dogs-carnivores-omnivores/>
- http://www.bbc.co.uk/schools/gcsebitesize/science/add_ocr_gateway/green_world/decayrev1.shtml
- Bacteria are single-celled microscopic organisms; Fungi are often larger organisms that include molds and mushrooms

2. **Commensalism** –a symbiotic relationship where one organism benefits (+) and the other organism is not harmed (0). Example, a remora attaches itself to the underside of a shark – The remora gets a free ride and free food (from eating shark's food scraps) while the shark does not get any benefits and harmed.

PARASITISM – One organism, the parasite, benefits (+), while the host is harmed (-). Example: tapeworm in the intestine of pigs; ticks on dogs and others

BIOACCUMULATION / BIOMAGNIFICATION

BIOACCUMULATION - Bioaccumulation is the gradual build up over time of a chemical in a living organism. This occurs either because the chemical is taken up faster than it can be used, or because the chemical cannot be broken down for use by the organism (that is, the chemical cannot be metabolized).

While the amount of pollutant might have been small enough not to cause any damage in the lowest levels of the food web, the amount might cause serious damage to organisms higher in the food web .

This phenomenon is known as biomagnification.

MAJOR TYPES OF ECOLOGICAL PYRAMIDS

A pyramid-shaped diagram representing quantitatively the numbers of organisms, energy relationships, and biomass of an ecosystem.

It depicts the number of individual organisms at different trophic levels of food chain. This pyramid was advanced by Charles Elton (1927), who pointed out the great difference in the number of the organisms involved in each step of the food chain. Successive links of trophic structure decrease rapidly in number until there are very few carnivores at the top.

The pyramid of number ignores the biomass of organisms and it also does not indicate the energy transferred or the use of energy by the groups involved. The lake ecosystem provides a typical example for pyramid of number

Teacher Tips:

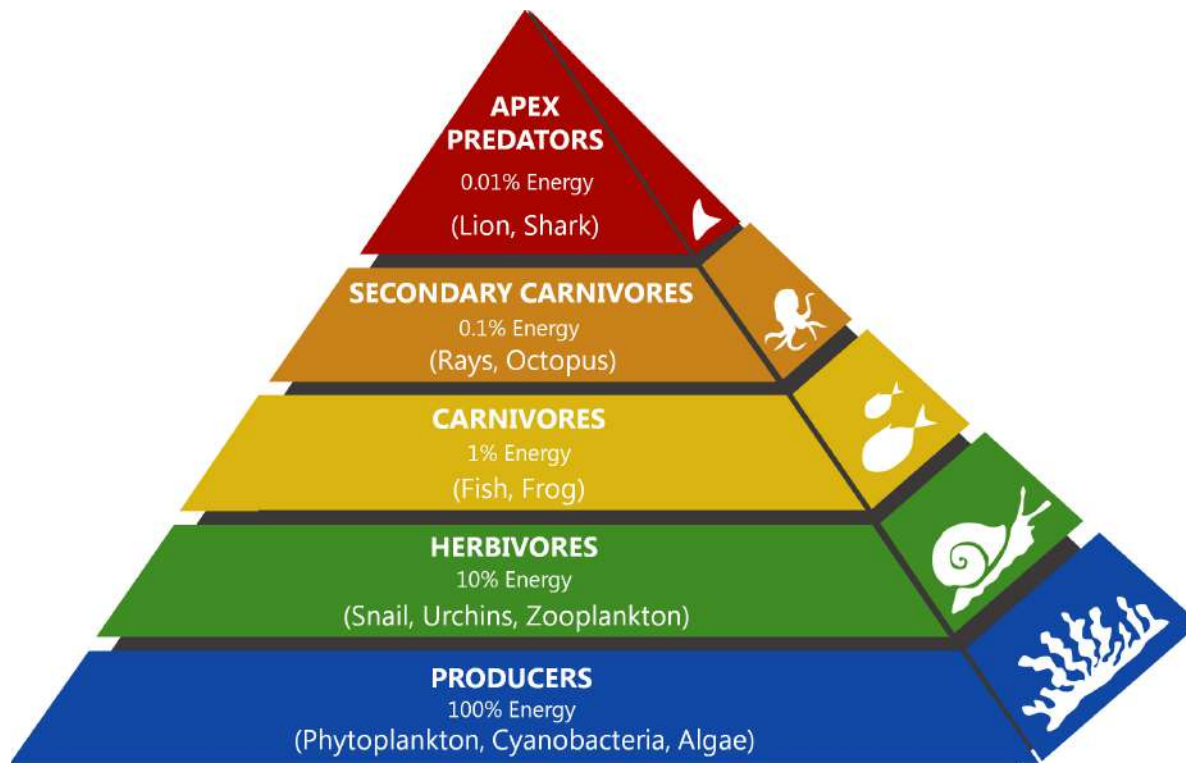
Read more: Bioaccumulation - Food, Pollutant, Toxic, and Fish - JRank Articles <http://science.jrank.org/pages/854/Bioaccumulation.html#ixzz3pyKY1U51>

Each stage in of the food chain is known as a trophic level.

There are fewer living organisms the higher you move up the trophic levels due to the loss of energy from one level to the next due to excretion and respiration, and transfer of heat to the atmosphere (second law of thermodynamics).

Also, living organisms become more complex as one moves up through the trophic levels. This means more lower level organisms are needed to support those above which creates a trophic pyramid. This is the reason why there are few top consumers in natural populations.

PYRAMID OF ENERGY



The biomass of the members of the food chain present at any one time forms the pyramid of the biomass. Pyramid of biomass indicates decrease of biomass in each trophic level from base to apex.

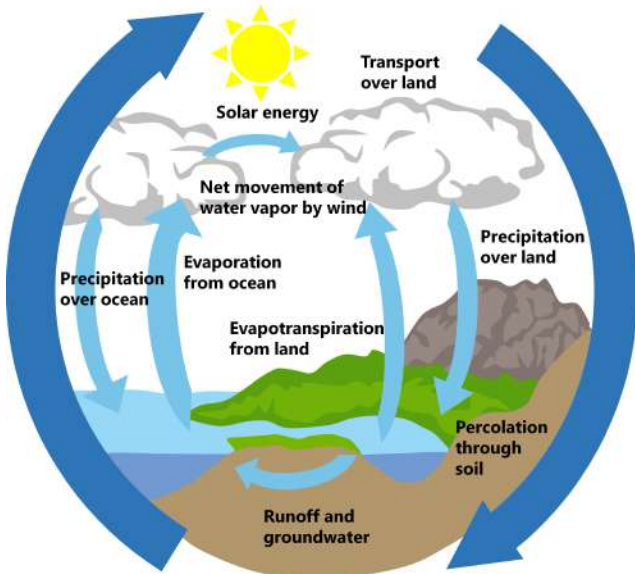
For example, the total biomass of the producers ingested by herbivores is more than the total biomass of the herbivores in an ecosystem. Likewise, the total biomass of the primary carnivores (or secondary consumer) will be less than the herbivores and so on.

When production is considered in terms of energy, the pyramid indicates not only the amount of energy flow at each level, but more important, the actual role the various organisms play in the transfer of energy. An energy pyramid illustrates how much energy is needed as it flows upwards to support the next trophic level.

The pyramid is constructed according to the rate at which food material (in the form of energy) passes through the food chain. Some organisms may have a small biomass, but the total energy they assimilate and pass on, may be considerably greater than that of organisms with a much larger biomass.

Energy pyramids are always sloping because less energy is transferred from each level than was paid into it. In cases such as in open water communities the producers have less bulk than consumers but the energy they store and pass on must be greater than that of the next level.

THE WATER CYCLE



Teacher Tip:

Presentation of cycles should be visual; Teachers can use power point presentation, drawings

Discuss the simple water cycle and how waters in aquifers are replenished. Relate to importance of forest, forest conservation, and reforestation.

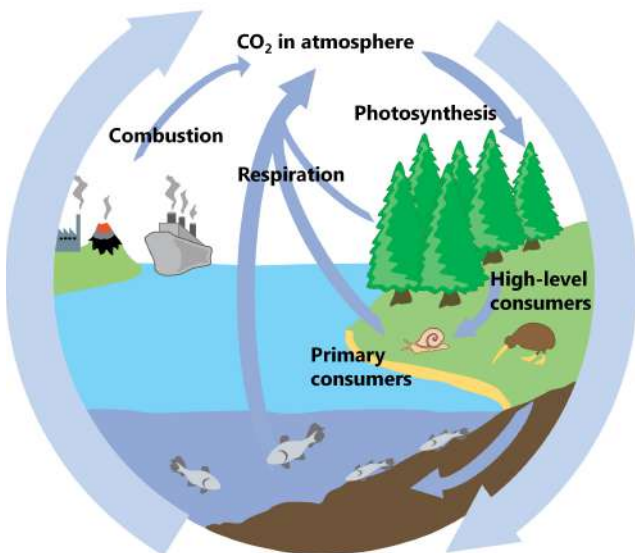
For definition of terms, please refer to <http://water.usgs.gov/edu/watercyclesummary.html>

Define the processes involved: Precipitation, evaporation, evapotranspiration, percolation. Relate with the importance of forests and tree planting, and sea water into aquifers.

An aquifer is an underground layer of water-permeable rock, rock fractures or unconsolidated material (gravel, sand or silt) from which groundwater can be extracted using a water well. <https://en.wikipedia.org/wiki/Aquifer>
Trees allow water to seep into the ground and reach the water table. As water seeps through the ground, it is filtered ('cleaned') and thus is the main source for clean water.

When water in the water tables is not replaced from other water tables, seawater can seep into the water table causing the water to become salty. This is called saltwater/seawater/saline intrusion.

THE CARBON CYCLE



CARBON

Define the processes involved:

Photosynthesis – fixes the carbon

Burning of fossil fuels and wood, cellular metabolism, decomposition – releases carbon in form of carbon dioxide.

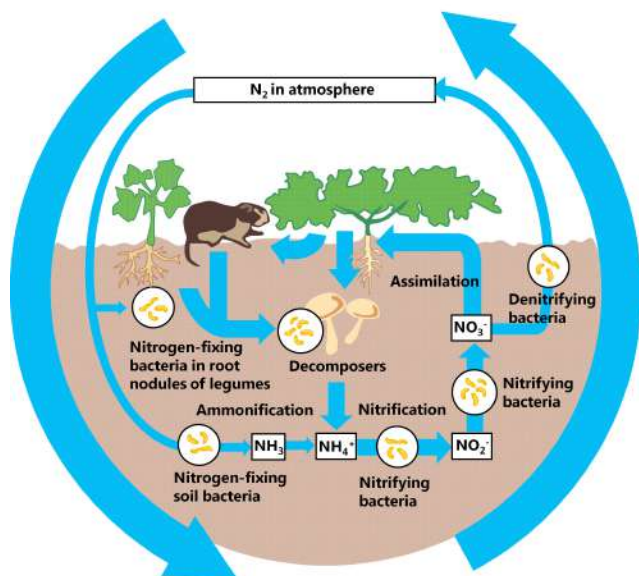
Discussion

With civilization, plant/forest cover decreased leading to increased carbon dioxide in the atmosphere. Increased atmospheric carbon dioxide has been shown to correlated to increased air temperatures.

Climate Change

- <http://www.climatechange.gc.ca/default.asp?lang=en&n=65CD73F4-1>
- <http://www.nrdc.org/globalwarming/>

THE NITROGEN CYCLE



1. Describe the cycle.
2. Define the processes involved in the cycle.
3. Discuss pollution related to the nitrogen cycle

Sources of knowledge:

<http://www.cas.miamioh.edu/mbi-ws/biogeochemicalcycles/Nitrogen/nitrogen.htm>

- <http://forages.oregonstate.edu/nfgc/eo/onlineforagecurriculum/instructormaterials/availabletopics/fertilization/nitrogen>
- <http://apcentral.collegeboard.com/apc/public/repository/nitrogen-cycling-in-ecosystems.pdf>

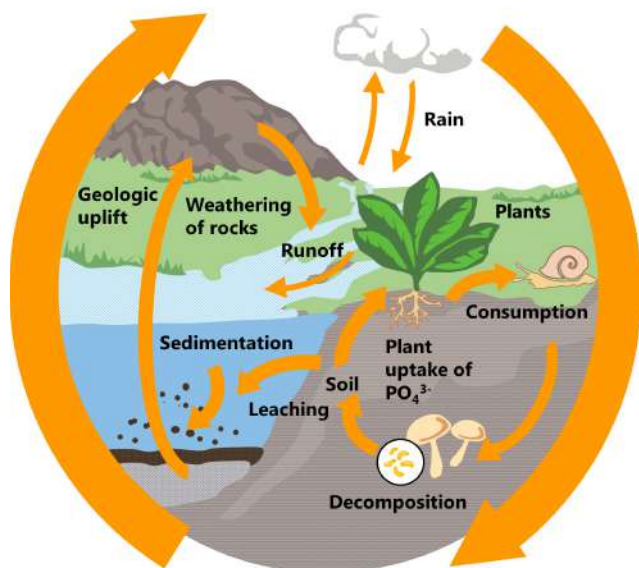
Sources for Discussion: Nitrogen Pollution

- <http://www.prep.unh.edu/resources/temp/NitrogenFactSheetSpring2012.pdf>
- <http://www2.epa.gov/nutrientpollution/problem>

Nitrogen dioxide is part of a group of gaseous air pollutants produced as a result of road traffic and other **fossil fuel combustion** processes. Its presence in air contributes to the formation and modification of other air pollutants, such as ozone and particulate matter, and to acid rain.

- <http://www.extraordinaryroadtrip.org/research-library/air-pollution/understanding-air-pollution/nitrogen-dioxide/health.asp>
- <http://www.greenfacts.org/en/nitrogen-dioxide-no2/index.htm#1>

THE PHOSPHORUS CYCLE



1. Describe the cycle.
2. Define the processes involved in the cycle.
3. Discuss pollution related to the nitrogen cycle

Sources of knowledge:

- <http://study.com/academy/lesson/phosphorus-cycle-steps-definition-diagram.html>
- <http://sciencelearn.org.nz/Contexts/Soil-Farming-and-Science/Science-Ideas-and-Concepts/The-phosphorus-cycle>
- <http://www.lenntech.com/phosphorus-cycle.htm>

PRACTICE (40 MINUTES)

Answer the vocabulary game - https://www.fcwa.org/story_of_water/html/vocabgame.htm

Group Activity:

1. Divide the class into groups of 4-5 students. Assign a discussion leader and secretary. Give the following guide questions to the leaders to facilitate the discussion. The teacher collects all the notes, summarizes them and leads an over-all class discussion.
 - a. If you were asked to conserve water, list the ways you can lessen the amount of water you personally use.
 - b. How does tree-planting help in increasing or maintaining a good quality environment?
 - c. Name man-made (anthropogenic) activities that will be detrimental to water quality and explain how.
2. Identify an area in your campus like a shallow pond or an area with plants/foliage. For the latter, provide students with long sticks for their investigation; if not provide pictures.
 - a. Instruction to students - If the area (or picture) were a small ecosystem, identify the different kinds of populations (use common names) and the communities present.
3. Demonstration of Transpiration: Locate several potted plants (wherein each plant can be divided into two almost equal bunches). Cover one bunch with a clear plastic bag and tie at the base; the other bunch, leave uncovered. Let the students examine their assigned plant every 1-2 hr (The teacher can adjust intervals with class schedule) at which they will record their observations on their notebooks.

Teacher Tip

Alternate: Teachers can make "Flashcards" for students to practice on one another.

ENRICHMENT (20 MINS)

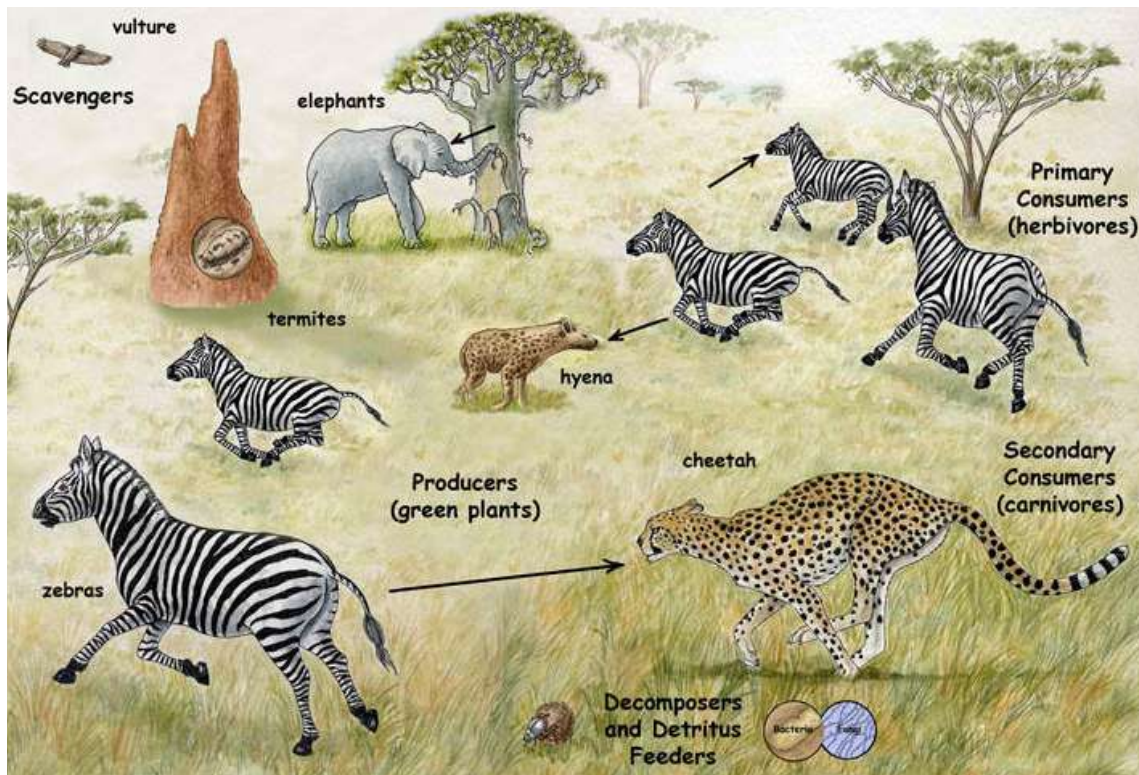
Students are required to submit a summary of the video on water conservation the next day.

1. Video - Water Use and Conservation: <http://education.nationalgeographic.com/media/water-use-and-conservation/>
2. Video - Water Conservation: How Water Management Can Lead to Sustainable Use <http://study.com/academy/lesson/water-conservation-how-water-management-can-lead-to-sustainable-use.html>

3. Case Study: "Indonesian Haze" - Submit a write-up of his/her understanding of the case study
<http://blog.cifor.org/36467/dont-inhale-scientists-look-at-what-the-indonesian-haze-is-made-of?fnl=en> and <http://www.dw.com/en/why-southeast-asias-haze-problem-persists/a-18715535>

Synthesis:

1. Molly Molecule is traveling down a river toward the ocean with other water molecules. Two months later, Molly is resting on a glacier in the mountains. Explain how this is possible. <http://www.cas.miamioh.edu/scienceforohio/water1/images/paa.pdf>



Teacher Tip:

Another exercise is to make the students picture the interior of their houses and ask them to identify the different populations and/or communities present. Lead the students to think of the small inhabitants in their houses – ants, termites, rats, cockroaches, lizards, fleas on their dogs and others.

Image source:

http://www.exploringnature.org/graphics/foodwebs/savannah_foodweb72.jpg

Using the illustration, ask the students to identify the different populations and communities of the ecosystem

EVALUATION (10 MINS)

- Which of the following encompass all the rest?
(A) Community (C) Population (E) Organ System
(B) Cells (D) Species (F) Molecules
- Which of the following processes are NOT involved in the water global cycle?
(A) Sublimation (C) Condensation (E) Run-off
(B) Infiltration (D) Evapotranspiration (F) Decomposition
- Which of the following does NOT describe carbon dioxide? It is ____.
(A) Emitted by many energy consuming devices, such as cars and powerplants.
(B) The waste gas breathed out by most animals.
(C) Precipitates from water and is stored in sedimentary rock.
(D) A by-product of cellular metabolism.
(E) Needed by plants for photosynthesis
- During the carbon cycle, which of the following carbon compounds would be utilized as an energy source by heterotrophs?
(A) Calcium carbonate
(B) Organic molecules
(C) Carbon dioxide
(D) Carbon monoxide
(E) Carbonic acid
- In the nitrogen cycle, the transformation of gaseous nitrogen into nitrogen-containing compounds is performed primarily by ____.
(A) Fungi (C) Green plants (E) Decomposers
(B) Bacteria (D) Herbivores

Source

<http://www.cas.miamioh.edu/scienceforohio/water1/images/paa.pdf>

Answer Key:

- A.
- F.
- C.
- B.
- B.

LEARNING COMPETENCY	ASSESSMENT TOOL	Exemplary (8-10)	Satisfactory (5-7)	Developing (3-4)	Beginning (1-2)
Describe the principles of the ecology S11/12LT-IVhj-28	Student participation (During lecture)	Student was able to answer the question without referring to his/her notes plus the follow-up question.	Student was able to answer the question without referring to his/her notes; Was not able to answer follow up question.	Student was able to answer the question but read from his/her notes.	(1) Student was not able to answer the question. (2) Student read from notes of his/her classmate.
	Vocabulary Game	Student was able to answer 80% of the questions correctly.	Student was able to answer 50-70% of the questions correctly.	Student was able to answer 30-40% of the questions correctly.	Student was able to answer 30-40% of the questions correctly.
	Group Discussion	Student's input was significant & thought provoking, and showed deep awareness of issue(s) discussed.	Student's input was significant, and showed awareness of issue(s) discussed.	Student's input did not show awareness of issue(s) discussed.	Student did not participate in the discussion.
	Evapotranspiration Exercise	Student submitted a comprehensive and detailed observation report.	Student submitted a comprehensive and report but some details were lacking.	Student submitted a report that was incomplete.	Student submitted a report that was copied from a classmate.
	Video Report on Water Conservation	Student submitted a report beyond the requirements.	Student submitted a comprehensive and well written report.	Student submitted a well written report but lacking in details.	Student did not submit an assignment/ submitted an unfinished report.
	Case Study: "Indonesian Haze"	Student submitted a well written report that showed the input of extra research effort.	Student submitted a well prepared and well researched report .	Student submitted a report that was lacking in details.	Student did not submit an assignment/ submitted an unfinished report.
	Examination	Obtained 90-100% correct answers in the exam	Obtained 70-80.99% correct answers in the exam	Obtained 50-69.99% correct answers in the exam	Obtained percentile <50% correct answers in the exam

Lesson 46: Interaction and Interdependence

Content Standard

The learners demonstrate an understanding of biotic potential and environmental resistance defined; population distribution and dispersal patterns; and population size and density.

Performance Standard

The learners shall be able to prepare an action plan containing mitigation measures to address current environmental concerns and challenges in the community.

Learning Competency

The learners categorize the different biotic potential and environmental resistance (diseases, availability of food, and predators) that affect population explosion **(S11/12-IVh-j-29)**

Specific Learning Outcomes

At the end of the lesson, the learners will be able to:

1. Define and differentiate biotic potential and environmental resistance
2. Illustrate and explain the different population distribution patterns
3. Differentiate population size and density
4. Understand the different mechanisms that regulated population density.

LESSON OUTLINE

Introduction	Communicate Learning Objectives	5
Motivation	Brief recapitulation	10
Instruction	Lecture and Group Discussion	90
Practice	Classroom exercises	40
Enrichment	Video	20
Evaluation	Submission of a reaction paper to a video or answer specific questions of the video	10

Materials

Laboratory equipment needed, raw materials, school supplies

Resources

- (1) Ecological Principles – <http://www.ecoliteracy.org/essays/ecological-principles> https://www.soinc.org/sites/default/files/uploaded_files/GG_HANDOUT-P1-ECOPRINCIPLES.pdf
- (2) Reece, L.A., M.I. Cain, S.A. Wasserman, P.V. Minorsky, R.B. Jackson 2011. Campbell's Biology. 9th Edition. Chapter 52-56.
- (3) Biotic Potential and Environmental Resistance - <http://ieng6.ucsd.edu/~pcchau/ENVR30/reader/txtbk/ch02c.pdf>
- (4) Population Ecology – <http://www.biology.iupui.edu/biocourses/N100H/ch39pop.html> <https://www.boundless.com/biology/textbooks/boundless-biology-textbook/population-and-community-ecology-45/human-population-growth-253/age-structure-population-growth-and-economic-development-935-12192/>
- (5) <http://www.shmoop.com/ecology/age-structure.html> <http://www.ck12.org/biology/Population-Size-Density-and-Distribution/lesson/Population-Size-Density-and-Distribution/> <http://www.cs.montana.edu/webworks/projects/stevesbook/contents/chapters/chapter002/section004/blue/page003.html> http://www.bio.miami.edu/tom/courses/bil160/bil160goods/16_rKselection.html

INTRODUCTION (5 MINS)

LEARNING OUTCOMES

1. Categorize the different biotic potential and environmental resistance (diseases, availability of food, and predators) that affect population explosion

TOPIC OUTLINE

- a. Biotic Potential and Environmental Resistance Defined
 - b. Population Distribution/Dispersal patterns
 - c. Population Size and Density
1. Factors that affect population size: Birthrate, death rate and movement.
 2. Estimating population density through growth models: Carrying capacity, Exponential vs Logistic Models
 3. Factors affecting population density:
 - a. Reproductive strategies (Semelparity vs Iteroparity; K- vs R- Strategists)
 - b. Density-Dependent vs Density-Independent Factors
 - c. Life tables (Age Structure, Survivorship Curves)

MOTIVATION (10 MINS)

1. Review levels of biological organization (Atom to biosphere) and orient students at what organizational level the discussion is at.
2. Review the definition of ecology: The study of the ecosystem which is composed of biotic (living) and abiotic (non-living) components.
3. Ask a question:
 - a. What is population explosion?
 - b. What causes population explosion?
 - c. Is there a human population explosion?

Teacher Tips:

For students to better understand the lesson, introduce the concept of “biotic potential and environmental resistance”. Afterwards, discuss the concepts of ecology at the population level.

Once done, students can be tasked to classify the various concepts learned into the two above categories and defend their answer(s).

INSTRUCTION/DELIVERY (90 MINS)

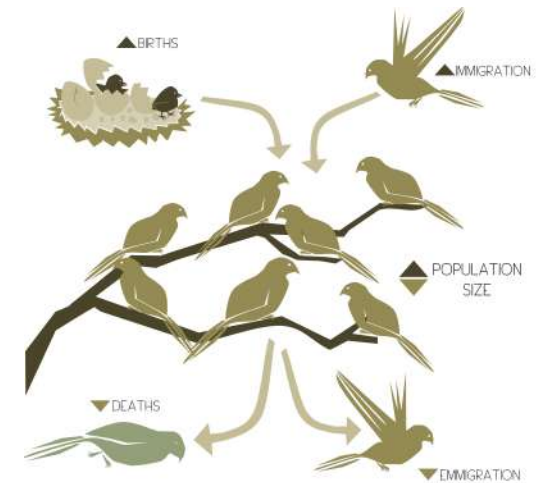
1. Introduce concepts of biotic potential and environmental resistance.
2. The rate of population growth is dependent on BIOTIC POTENTIAL and ENVIRONMENTAL RESISTANCE.
 - a. Biotic potential measures how well a species has adapted to survive (by defense mechanisms, resistance to adverse conditions, migration, and seed dispersion)
 - b. Environmental resistance is adverse biotic and abiotic factors that raise the death rate of a population. Example: predators, parasites, unfavorable temperature, and lack of water.
3. The combination of the biotic and abiotic factors determines the CARRYING CAPACITY of an ecosystem. Carrying capacity is the optimal maximum density of a population can be supported by a defined space. If the population approaches or exceeds the carrying capacity, competition for resources will set limits to the population density.
4. Population explosion is a result when all conditions favorable to the population occurs for an extended period of time.

DISTRIBUTION/DISPERSAL is the pattern of spacing among individuals of the population. Three types:

- a. **CLUMPED** dispersion - individuals aggregate in patches; may be influenced by resource availability and behavior (efficiency in hunting, guarding the young).
- b. **UNIFORM** dispersion - individuals are evenly distributed; May be influenced by social interactions such as territoriality.
- c. **RANDOM** dispersion - The location of one individual is independent of others members of the population.

POPULATION SIZE and DENSITY

Population size is the number of individuals in a population. For example, a population of insects might consist of 100 individual insects, or many more. Population size influences the chances of a species surviving or going extinct. Generally, very small populations are at greatest risk of extinction. Population density is the average number of individuals in a population per unit of area or volume. For example, a population of 100 insects that live in an area of 100 square meters has a density of 1 insect per square meter. If the same population lives in an area of only 1 square meter, what is its density? Which population is more crowded? How might crowding affect the health of a population?



Teacher Tip:

Student population size of school – All students
Example: 2,000 students
Student density – Number of students divided by the total size of the campus
Example: If campus is 2 ha, density is 1,000 students per hectare.

Population density is not static. It is influenced by death, birth, and movement (immigration and emigration) among populations.

POPULATION GROWTH is due to a higher birth rate than death rate. New individuals are recruited into the population through growth and immigration. The maturation of newborn into the adult breeding population, is considered a more important basis of the potential population growth.

ESTIMATING POPULATION DENSITY THROUGH GROWTH MODELS:

Carrying capacity, Exponential vs Logistic Models

Population growth models discuss the rate at which the density of a population increases through time.

Exponential Growth Curve

- Is population increase under idealized conditions
The rate of reproduction is at its maximum, called the intrinsic rate of increase
Cannot be sustained for long in any population
- The J-shaped curve of exponential growth is a characteristic of some populations that are rebounding.
- A more realistic population model incorporates the carrying capacity (represented by k) of the environment.

Review: Carrying capacity is the optimal maximum density of a population can be supported by a defined space. If the population approaches or exceeds the carrying capacity, competition for resources will set limits to the population density.

Logistic Growth Curve

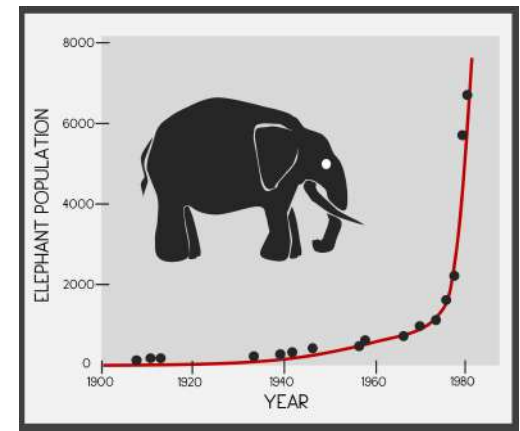
As populations grow, the resources become limited.

When the increase in animal population is plotted over a long period, the early increase is rapid, then gradually slows down as the carrying capacity is reached.

The pattern in which the growth of the population slows down as it reaches k is called logistic growth curve.

Teacher Tip:

- Factors that increase population size:
Birth and Immigration
- Factors that decrease population size:
Death and Emigration



Populations are not only affected by the availability of resources but also the presence of natural enemies/predators, parasites and competition with other species. These mortality factors can be classified into:

1. Density-dependent–mortality factor whose influence varies with the density of the population; may reduce population densities and stabilize them at equilibrium levels. Examples: parasitism, predation, competition. More individuals of the population are killed when densities are high and less when densities are low. Predators kill relatively few of prey species that is rare; they kill relatively more of the common species.
2. Density-independent – Mortality factor whose influence is not affected by changes in the population size or density.
3. They are physical factors like storms, drought, fires, floods.

FACTORS AFFECTING POPULATION DENSITY

1. Number of Reproductive Events: Semelparity vs. Iteroparity
 - A. Semelparity – (“Semel” - Latin “once”): Organisms can produce all their offspring in one reproductive event. Common in insects and some invertebrates, salmon, bamboo grasses and agave plants. They reproduce only once and die. Agaves live to several years before reproducing; Some are annual plants that develop from seed, flower and drop their own seed within a year.
 - B. Iteroparity – (“itero” L = to repeat); Pattern of repeated reproduction at intervals; common in most vertebrates and perennial plants such as trees; number of reproductive events and number of offspring per event vary among species.
 - i. Seasonal Iteroparity – Have distinct breeding seasons such as temperate animals and forest trees.
 - ii. Continuous Iteroparity – individuals reproduce repeatedly and at any time of the year; found in tropical species, parasites and many mammals.

Number of Offsprings per Reproductive Event

Organisms that live in stable environments tend to make few, "expensive" offspring. Organisms that live in unstable environments tend to make many, "cheap" offspring.

Teacher Tip:

Use Philippine examples:

Natural predators of

Rats – Cats, snakes, owls Mosquitoes – house lizards Earthworms – chickens, maya (bird) Ants – ant lions

Density-dependent mortality

The animals can be changed into a rat (prey) and snake (predator) and location – sugar cane fields of Negros Oriental.

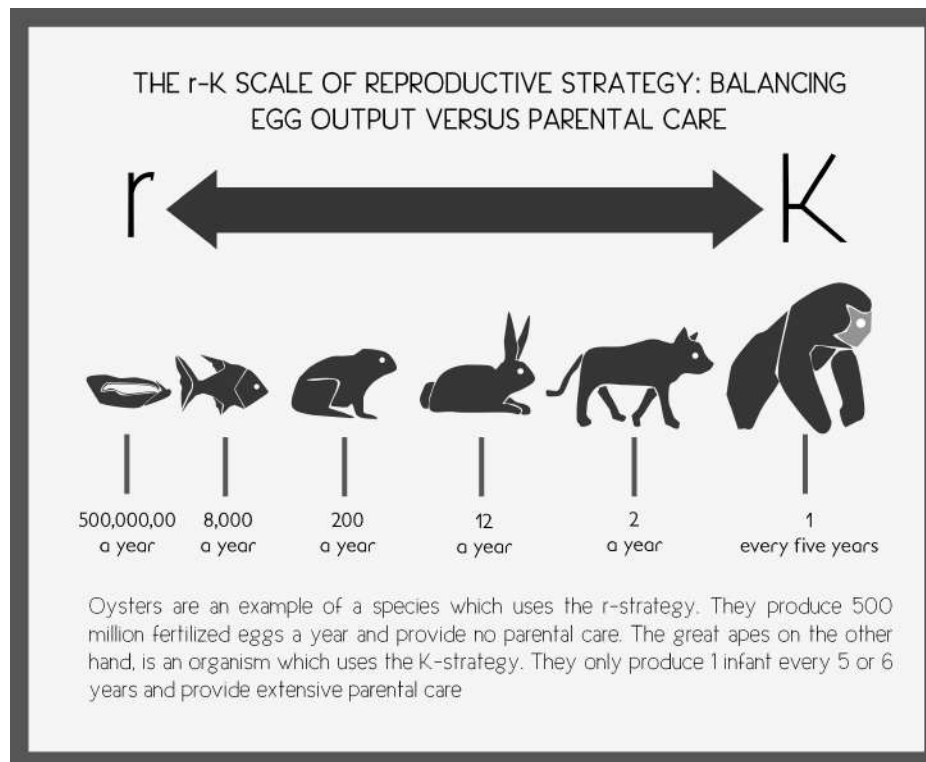
The density of predator species follows the trend of the prey.

(1) r – strategists

These animals live in unstable environments and the ability to reproduce rapidly (exponentially) is important. Such organisms have high fecundity, give relatively little parental care in any one offspring, and are vulnerable to predation and the “dictates” of their environment. The “strategic intent” is to flood the habitat with progeny so that, regardless of predation or mortality, at least some of the progeny will survive to reproduce. Organisms that are r-selected have short life spans, are generally small, quick to mature and waste a lot of energy.

(2) k – strategists

They are larger in size and have longer life expectancies. They are stronger or are better protected and generally are more energy efficient. They produce, during their life spans, fewer progeny, but place a greater investment in each. The resulting offspring have higher chances of survival. Their reproductive strategy is to grow slowly, live close to the carrying capacity of their habitat and produce a few progeny each with a high probability of survival.



Teacher Tip:

Fecundity [fe-kun'dī-te] -

The ability to produce offspring frequently and in large numbers. In demography, the physiological ability to reproduce, as opposed to fertility.

(<http://medical.dictionary.thefreedictionary.com/fecundity>)

Source for description of r- and k-strategists

<http://www.cs.montana.edu/webworks/projects/stevesbook/contents/chapters/chapter002/section004/blue/page003.html>

Examples for r-strategists: Broadcast spawners like some fishes (salmon, bangus), invertebrates (corals, insects)

Examples for k-strategists: Large mammals (humans, whales, monkeys, cats, dogs). Ask students to give examples.

Teacher Tip:

<https://e7xavierbiology.wikispaces.com/r+and+K+Strategies+are+Extremes>

Oysters are at the extreme end of the r selected breeder spectrum due to the high amount of offspring that they produce (500,000,000). They do not provide parental support for their offspring and are small animals. On the other hand gorillas are on the extreme at the end of the K-selected breeder spectrum since they only have one offspring every 5 years.

Neither strategy is better than the other since both strategies are necessary for the biosphere. K-strategists help maintain ecosystem constancy (climax / equilibrium species) while r-strategists quickly cover disturbed areas and help decompose dead plants and animals (pioneering/opportunistic species).

POPULATIONS are regulated by

(A) Density-Dependent Regulation

Population growth rates are regulated by the density of a population.

Most density-dependent factors are biological (biotic) in nature and includes predation, inter- and intra-specific competition, accumulation of waste, and diseases such as those caused by parasites. Usually, the denser a population is, the greater its mortality.

(B) Density-Independent Regulation

Factors that are typically physical or chemical (abiotic) in nature that influence the mortality of a population regardless of its density. They include weather, natural disasters (storms, forest fires, flooding, pollution and others). Example, a bird may be killed during an oil spill regardless of how many birds were present in that area. Its chances of survival are the same whether the population density is high or low.

DENSITY-DEPENDENT REGULATION

(A) Competition for Resources

Increasing population density intensifies competition for nutrients and other resources, reducing reproductive rates.

(B) Predation

Predation can be an important cause of density- dependent mortality if a predator captures more food as the population density of the prey increases. As a prey population builds up, predators may also feed preferentially on that species. Predator-prey relationship of some animals like the snowshoe hare and the lynx demonstrate a cyclic pattern.

Teacher Tip:

Source: Boundless. "Density-Dependent and Density-Independent Population Regulation." Boundless Biology Sep. 2015. Retrieved 28 Oct. 2015 from <https://www.boundless.com/biology/textbook/boundless-biology-textbook/population-and-community-ecology-45/environmental-limits-to-population-growth-251/density-dependent-and-density-independent-population-regulation-931-12187/>

(C) Territoriality

Territoriality can limit population density when space becomes the resource for which individuals compete. Cheetahs (*Acinonyx jubatus*) use a chemical marker in urine to warn other cheetahs of their territorial boundaries. The presence of surplus, or nonbreeding, individuals is a good indication that territoriality is restricting population growth.

(D) Disease

If the transmission rate of a disease increases as a population becomes more crowded, then the disease's impact is density dependent. In humans, the respiratory diseases influenza (flu) and tuberculosis are spread through the air when an infected person sneezes or coughs. Both diseases strike a greater percentage of people in densely populated cities than in rural areas.

LIFE TABLE

Life history tables, or life tables, are a method of quantifying population structure that addresses all of the above population traits.

Life tables provide age- specific information on survival and fecundity rates for a particular population.

Information contained in a life table:

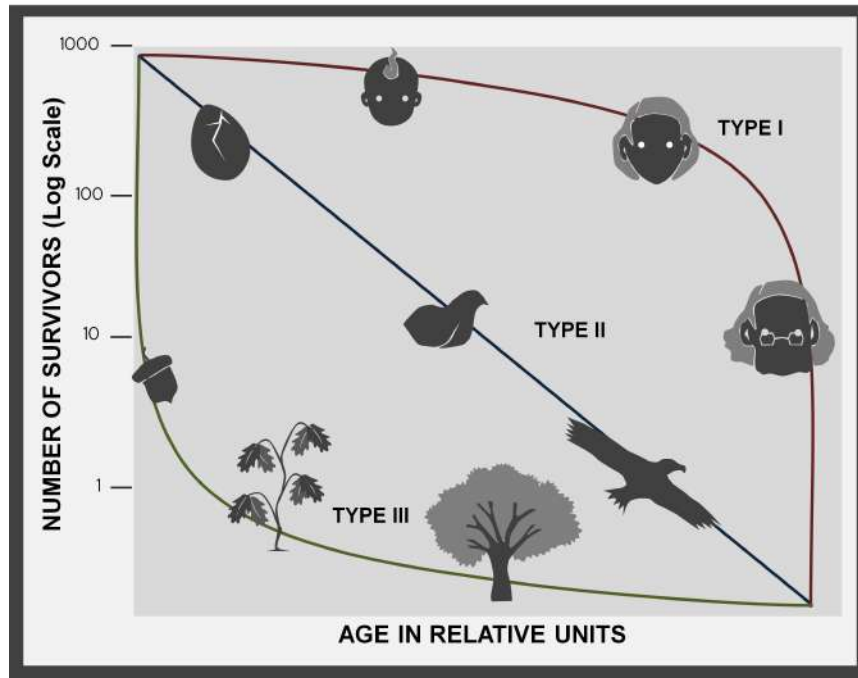
- (A) Population age structure – number of individuals that are young, old and of reproductive age;
- (B) Population growth rate – Is the population size growing (or shrinking)?
- (C) Population survivorship patterns – At what stage does most mortality occur? Does most mortality occur in the very young? The very old? Or equally across all ages?

1. Population Age Structure

Also called population pyramid.

It is a visualization of the number of individuals in different age classes and incorporates the male to female sex ratio in that population. Can describe the population as increasing (rapidly or slowly), stable and decreasing.

- 2. Population Growth** – previously discussed (see Population Growth Models)
- 3. Population Survivorship patterns**



Teacher Tip:

A survivorship curve is a graph showing the number or proportion of individuals surviving to each age for a given species or group (e.g. males or females). Survivorship curves can be constructed for a given cohort (a group of individuals of roughly the same age) based on a life table.

A survivorship curve is a graph showing the number or proportion of individuals surviving to each age for a given species or group (e.g. males or females). Survivorship curves can be constructed for a given cohort (a group of individuals of roughly the same age) based on a life table.

SURVIVORSHIP CURVE

1. Graphic representation of the number of individuals in a population that can be expected to survive to any specific age.
2. There are three general types of curves:
 - A. Type I - has a high death rate (or low survivorship rate) immediately following birth. (ex. small mammals, fishes, and invertebrates)
 - B. Type II - The organism tends to live a long life (low death rate and a high survivorship rate); toward the end of its life expectancy, however, there is a dramatic increase in the death rate. Example: large mammals
 - C. Type III - The mortality or survivorship rate is relatively constant during the organism's entire life. Example: birds and mice.

PRACTICE

PRACTICE QUESTIONS

Differentiate between the following:

1. Exponential vs. Logistic Growth (use illustrations)
2. Density - dependent vs Density-independent regulation
3. R-vsK-strategists
4. Immigration vs. Emigration
5. Population Size vs. Population Density
6. Survivorship patterns
7. Age structure pyramids

Source: http://www.crazyteacherlady.com/uploads/5/1/4/8/5148626/objective_2_activities_pop_growth.pdf

SMALL GROUP DISCUSSIONS

The human population is currently growing at an exponential rate. Since you have learned that populations cannot grow forever, what are some things (more than one!) that could happen when the human population reaches its carrying capacity?

Source: http://www.crazyteacherlady.com/uploads/5/1/4/8/5148626/objective_2_activities_pop_growth.pdf

Teacher Tips:

The amount of resources is not the only limiting factor that depends on a population's density. Diseases and parasites can limit a population's growth once the population reaches a certain number of organisms.

The more organisms there are, the faster a disease can spread or a parasite can be transferred to another organism because there are more available hosts that are near each other.

Competition for resources—either between the same species or two different species—will also decrease a population's size. Resources are limited in any habitat, and, when populations reach a certain size, there will not be enough to go around.

Using the historical data of Philippine population from 1955-2015, the students construct a graph with time on the x-axis and population on the Y- axis.

Points for discussion:

1. Advantages and disadvantages of population growth in the Philippines.
2. Their views on the reproductive health bill

Before the session, the reading assignment for students is the REPRODUCTIVE HEALTH BILL.

EVALUATION

Recall the population dynamic for the lynx and hare in Canada. Suppose there is a change in the ecosystem (perhaps climate change) such that the magnitude of the oscillation for both the lynx and hare populations becomes much larger. What is a likely consequence of this perturbation?

- A. It would lead to greater average stability of the two populations.
- B. There is a greater risk of local extinction for one or both populations.
- C. The hare population is likely to stabilise more than the lynx population.
- D. There would be no real consequence over a number of years.

The mortality rate of organisms following a type III survivorship curve is:

- A. fairly constant throughout life
- B. higher in post-productive years
- C. lower after the organisms become established
- D. unrelated to age

Organisms whose life history adaptation is called semelparity produce ____.

- A. young only late in life
- B. a large batch of young and die
- C. young over most of their life
- D. a single offspring near the end of their reproductive potential

Which dispersion pattern is most common in nature?

- A. randomly spaced
- B. uniformly spaced
- C. clumped
- D. all are equally common
- E. none of these are found in nature

r strategists tend to have

- A. few offspring
- B. little parental care
- C. sigmoid growth curves
- D. all of the above
- E. none of the above

Reading Assignment

The Responsible Parenthood and Reproductive Health Act of 2012 (Republic Act No. 10354), informally known as the Reproductive Health Law or RH Law: <https://rhbillresourcepage.wordpress.com/the-rh-law-republic-act-no-10354/>

Students are required to submit a research paper on the RH Law.

- First Part: On the pros and cons of the law – Student should cite references of the various opinions that they have read.
- Second Part: Write their personal views about the law.

LEARNING COMPETENCY	ASSESSMENT TOOL	Exemplary (8-10)	Satisfactory (5-7)	Developing (3-4)	Beginning (1-2)
Categorize the different biotic potential and environmental resistance (diseases, availability of food, and predators) that affect population explosion S11/12-IVhj-29	Student participation (During lecture)	Student was able to answer the question without referring to his/her notes plus the follow-up question.	Student was able to answer the question without referring to his/her notes; Was not able to answer follow up question.	Student was able to answer the question but read from his/her notes.	(1) Student was not able to answer the question. (2) Student read from notes of his/her classmate.
	Group Discussion	Student's input was significant & thought provoking, and showed deep awareness of issue(s) discussed.	Student's input was significant, and showed awareness of issue(s) discussed.	Student's input did not show awareness of issue(s) discussed.	Student did not participate in the discussion.
	Student participation (Practice)	Student was able to answer the question concisely.	Student was able to answer the question without referring to his/her notes; Was not able to answer follow up question.	Student was able to answer the question but read from his/her notes.	(1) Student was not able to answer the question. (2) Student read from notes of his/her classmate.
	Research Paper	Student submitted an impressive research paper that beyond the teacher's expectations.	Student submitted a comprehensive and well written research paper.	Student submitted a well written research paper; but some questions lack in details.	(1) Student did not submit an paper (2) Student submitted a poorly written paper.
	Examination	Obtained 90-100% correct answers in the exam	Obtained 70-80.99% correct answers in the exam	Obtained 50-69.99% correct answers in the exam	Obtained percentile <50% correct answers in the exam

Lesson 47: Interaction and Interdependence

Content Standard

The learners demonstrate an understanding of terrestrial and aquatic ecosystems and how human activities affect the natural ecosystem.

Performance Standard

The learners shall be able to prepare an action plan containing mitigation measures to address current environmental concerns and challenges in the community.

Learning Competency

The learners describe how the different terrestrial and aquatic ecosystems are interlinked with one another **(S11/12-IVhj-30)**

Specific Learning Outcomes

A the end of the lesson, the student should be able to:

1. Characterize the different biomes of the world;
2. Characterize the different terrestrial and aquatic ecosystems.
3. Discuss the connectivity of terrestrial and aquatic ecosystems.
4. Discuss how the human populations affect ecosystems.

LESSON OUTLINE

Introduction	Communicate Learning Outcomes	10
Motivation	Short discussion on ecological problems of the Philippines	40
Instruction	Lecture and discussion	120
Practice	Class discussion	60
Enrichment	Video	30
Evaluation	Submission of an essay, a journal and exams	10

Materials

Laboratory equipment needed, raw materials, school supplies

Resources

- (1) Ecological Principles – <http://www.ecoliteracy.org/essays/ecological-principles> https://www.soinc.org/sites/default/files/uploaded_files/GG_HANDOUT-P1-ECOPRINCIPLES.pdf
- (2) Reece, L.A., M.I. Cain, S.A. Wasserman, P.V. Minorsky, R.B. Jackson. 2011. Campbell's Biology. 9
- (3) Chapter 52-56. Community ecology - <http://www.ck12.org/book/CK-12-Biology-I-Honors-CA-DTI3/section/16.4/> - http://www.globalchange.umich.edu/globalchange1/current/lectures/ecol_com/ecol_com.html Biomes - <http://classroom.synonym.com/difference-between-biome-ecosystem-6468.html> Edition.

INTRODUCTION (10 MINS)

LEARNING OUTCOMES:

1. Describe how the different terrestrial and aquatic ecosystems are interlinked with one another

TOPIC OUTLINE:

- a. World and Philippine biomes;
- b. Aquatic ecosystems (freshwater, estuarine, marine)
- c. Marine communities.
- d. Connectivity of terrestrial and aquatic ecosystems.

Review

- A. Terminology:
 1. Ecology and ecosystem,
 2. Population vs Communities
 3. Endemic vs Exotic Species
 4. Biome vs Ecosystem
- B. Review levels of organization and the orient students the level of the lesson.

MOTIVATION (40 MINS)

Introduce ecosystem interconnectivity by starting a short discussion on local phenomena (like floods, red tide blooms, and others), local problems (like garbage, pollution), and recurring diseases (dengue). Ask them what may be the causes of these problems and how these affect the ecosystem. Ask students what is their understanding of “ecological balance”. Once all answers have been elicited from students, summarize their answers.

Teacher Tip:

At the start of the unit on “Interaction and the Interdependence”, inform the students to prepare a research paper on the impacts of humans on the ecosystem. Their research will be the basis for group discussion.

Topic suggestions:

- (1) Garbage Gyres of the World Oceans
- (2) Plastics, types of plastics and recycling of plastic.
- (3) Introduced Species – Green Apple Snail
- (4) Climate Change (Patterns of Frequency and Strength of Philippine Typhoons)

Teacher Tip:

This is a way of evaluating the level of ecological awareness of the students.

INSTRUCTION (120 MINS)

1. Biomes are major types of major types of ecosystems: Aquatic and Terrestrial Biomes.
2. The aquatic biomes (freshwater and marine) occupy most of the biosphere in terms of area.
3. The terrestrial biomes are often named for major physical or climactic factors and for their predominant vegetation.

AQUATIC BIOMES

1. Ecologists distinguish between freshwater biomes and marine biomes on the basis of physical and chemical differences.
2. Since oceans comprise about 75% of the Earth's surface, oceans have an enormous impact on the biosphere.
3. Aquatic Biomes:
 - a. The evaporation of seawater provides most of the Earth's rainfall;
 - b. Ocean temperatures have a major effect on world climate and wind patterns;
 - c. Marine plants and algae, and photosynthetic bacteria supply a significant portion of the world's oxygen and consume large amounts of carbon dioxide; and
 - d. Freshwater biomes are closely linked to the soils and biotic components of terrestrial biomes.
4. Characteristics of aquatic biomes is based on the Vertical stratification of physical and chemical variables:
 - a. Photic vs Aphotic zone
 - i. Photic zone – Sufficient sunlight is available for photosynthesis and is the basis of the food chain;
 - ii. Aphotic zone – Sunlight cannot penetrate and food chain is based on non-photosynthetic activities.
 - b. Temperature
 - i. Surface waters are usually distinctly warmer than deeper waters. Between these layers, is a layer wherein water temperature rapidly changes (called THERMOCLINE).
5. At the bottom of all aquatic biomes is the BENTHIC ZONE that can be made up of the sediment that can be composed of sand/silt/clay and organic/inorganic materials. Animals living in the benthic zone are called BENTHOS.

Teacher Tip:

Example, marine biomes generally have salt concentrations that average 3% while freshwater biomes are usually characterized by a salt concentration of <1%.

Resources:

Photic vs aphotic Figure: Source
<https://www.boundless.com/biology/textbooks/boundless-biology-textbook/ecology-and-the-biosphere-44/aquatic-biomes-247/abiotic-factors-influencing-aquatic-biomes-916-12172/>

Thermocline Figure: Reference
<https://quizlet.com/10292541/8th-chapter-13-ocean-systems-flash-cards/>

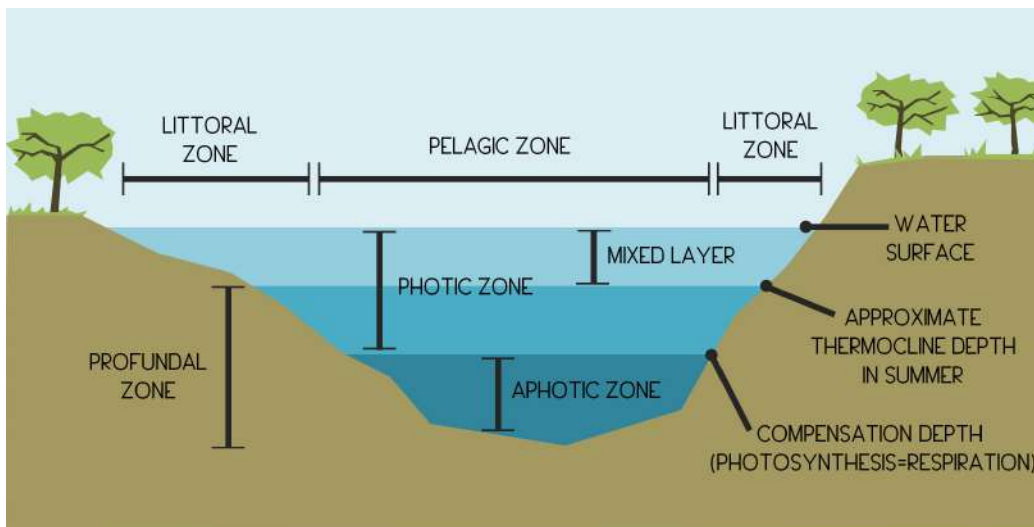
FRESHWATER BIOMES

<http://www.ucmp.berkeley.edu/exhibits/biomes/freshwater.php>

1. Particular characteristics of a freshwater biomes are influenced by the patterns and speed of water floor, and the climate to which the biome is exposed. There are three general categories:
 - a. Standing bodies of water (Example: lakes and ponds)
 - b. Moving bodies of water (Example: rivers and streams)
 - c. Wetlands

LAKES

1. Zonation
 - a. Littoral zone – Shallow, well-lit waters close to the shore
 - b. Limnetic zone – Well-lit, open surface waters farther from the shore
 - c. Profundal zone – Aphotic region of the water column.
2. Classification according to production of organic matter
 - a. Eutrophic - Having waters rich in phosphates, nitrates, and organic nutrients that promote a proliferation of plant life, especially algae. Some lakes and bodies of water can become eutrophic through high nutrient input from domestic and agricultural sources.
 - b. Oligotrophic - has low nutrient concentrations and low plant growth.



Teacher Tip:

At the end of the session, discuss the threats of freshwater biomes. Before the discussion, ask the students about possible threats. (<http://www.ucmp.berkeley.edu/glossary/gloss5/biome/aquatic.html>)

Threats to freshwater biomes (Lakes):

1. Introduction of exotic species (species that are not found in the lake) by aquaculture.
2. Pollution
3. Eutrophication

RIVERS AND STREAMS

1. These are bodies of flowing water moving in one direction.
2. They get their starts at headwaters, which may be springs, snowmelt or even lakes, and then travel all the way to their mouths, usually another water channel or the ocean.
3. The characteristics of a river or stream change during the journey from the source to the mouth.
 - a. Source: Water is clearer with high oxygen levels and its temperature is cooler
 - b. Towards the middle part, the width increases, as does species diversity — numerous aquatic green plants and algae can be found.
 - c. Toward the mouth, the water becomes murky from all the sediments that it has picked up upstream, decreasing the amount of light that can penetrate through the water. Since there is less light, there is less diversity of flora, and oxygen levels are lower.

WETLANDS

1. Defined – an area with water that supports aquatic plants; range from periodically flooded regions to soil that is permanently saturated during the growing season.
2. Wetlands range from marshes to swamps to bog that develop in:
 - a. Basin wetlands – develop in shallow basins, ranging from upland depressions to filled-in lakes and ponds;
 - b. Riverine wetlands – develop along shallow and periodically flooded banks of rivers and streams;
 - c. Fringe wetlands - occur along coasts of large lakes and seas, where water flows back and forth because of rising lake levels or tidal action

MARINE BIOMES

Marine regions cover about three-fourths of the Earth's surface and include deep sea/oceanic communities, nearshore communities (coral reefs, seagrass beds, algal [kelp/*Sargassum*] beds, mangrove forests) and estuaries. Produces in marine biomes contribute to the supply of the world's oxygen supply and like terrestrial vegetation, take in a huge amount of atmospheric carbon dioxide. As a huge water reservoir, evaporation of the seawater provides rainwater for the terrestrial biomes.

Threats to freshwater biomes (Rivers):

1. Re-channeling of natural freshwater ways or rivers for fishponds, rice paddy irrigation and human use;
2. Sand Quarrying – deepens rivers and prevents river water from exiting and allows seawater intrusion, and prevents oxygenation of water
3. Stone quarrying – removes defense of organisms against being swept away by water current;
4. Dams – prevents migration of fish; use as receiving bodies for pollutants
5. Pollution
6. Eutrophication

Teacher Tip:

The definition of “Wetlands” is very broad that even practitioners are debating on the limits of fringe wetlands since it encroaches on both freshwater and marine biomes. Ecologists, however, clearly differentiate freshwater and marine biomes from wetlands. To avoid confusion among students, discuss the overlap of the terms.

ZONATION OF MARINE BIOME

1. Horizontal Division - zonation extending from land to sea

A. Coastal / Nearshore Zone

- i. Intertidal (Littoral) Zone – The region between the high and low tidal marks. The hallmark of the intertidal is the constant motion of water in the form of waves, tides and currents.
- ii. Supratidal (Supralittoral) Zone – This is the region of the coast that is permanently exposed to air but occasionally becomes wet by large waves and sea spray.
- iii. Subtidal/sublittoral/Infralittoral Zone – This region is always submerged in seawater although water depth changes with the tides.

B. Pelagic Zone – This can be divided into

- i. Neritic Zone – is the shallow water zone (<200 m) above the continent shelf.
- ii. Oceanic Zone – compose waters beyond the continental shelf (>200 m). Oceanic – b

2. Vertical Division – based on depth; similar to vertical division of lake

A. Photic/Euphotic Zone

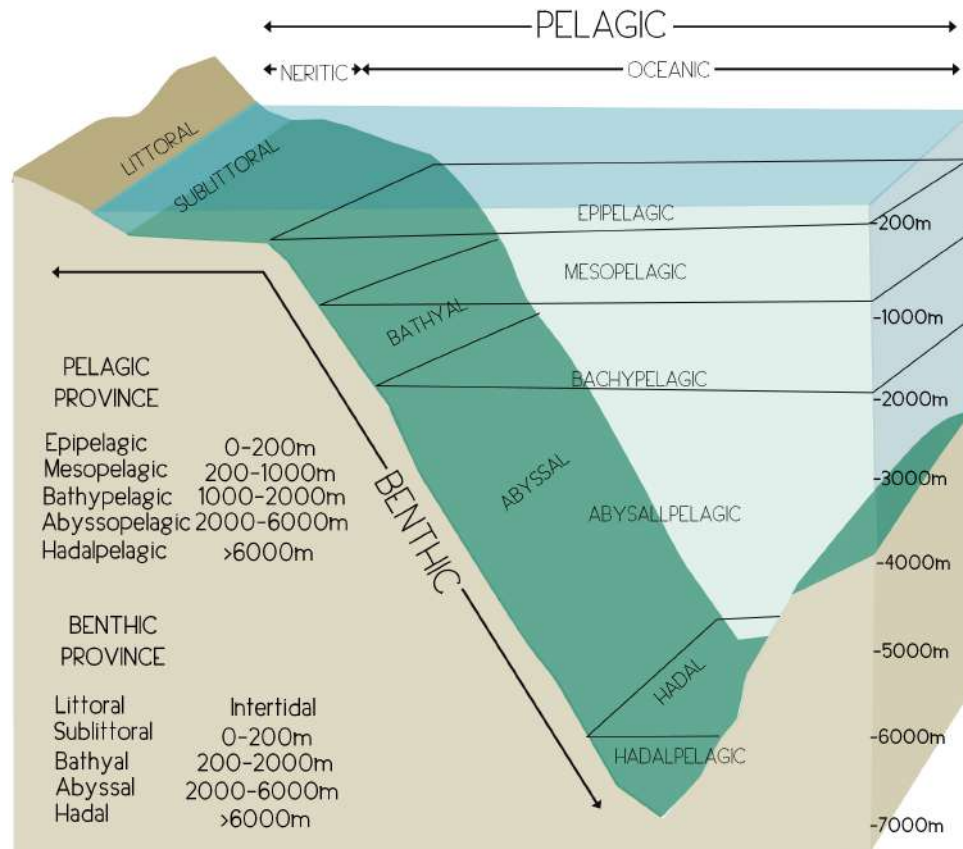
- i. Sunlight only penetrates the sea surface to a depth of about 200 m, creating the photic zone. Organisms that photosynthesize depend on sunlight for food and so are restricted to this zone. Depending on water clarity, the bottom of this zone is about 500 ft below sea level. It is also known as the epipelagic zone.

B. Aphotic Zone

- i. Comprises of the reminder of the water column below the photic zone. Food chains usually begin with detritus, living algae and bacteria that sink from the above layers. It can be further subdivided to:
 - a. Mesopelagic Zone – 500-3,280 ft below sea surface
 - b. Bathypelagic Zone – 3,280-13,000 ft below sea surface
 - c. Abyssopelagic Zone – 13,00-20,000 ft below sea level
 - d. Hadal Zone – 20,000-35,000 ft below sea water
- ii. Depending on water clarity, the bottom of this zone is about 500 ft below sea level. It is also known as the epipelagic zone.

Teacher Tip:

Some references includes the coastal zone as part of the neritic zone while others consider the coastal zone as distinct and separate from the neritic zone.



Marine Communities

(1) Nearshore Communities

A. Estuaries, Mangrove Forests and Salt Marshes

Salt Marshes, estuaries, and mangrove forests are unique ecosystems in semi-sheltered areas near the ocean coastline. These areas often serve as nursing grounds where young marine life is protected during development.

A salt marsh is a marshy area found near estuaries and sounds. The water in salt marshes varies from completely saturated with salt to freshwater. Estuaries are partly sheltered areas found near river mouths where freshwater mixes with seawater. Both salt marshes and

estuaries are affected by high and low tides. Mangrove forests are found in the intertidal zone of tropical coastlines and estuaries, commonly in the tropical coastal areas of Australia, Africa, North and South America between 32° N and 38° S. Mangrove forests are made up of different types of mangrove trees and a wide variety of plants. The mangrove tree is a tree with roots and leaves that filter salt and other materials. Different mangrove species are adapted to serve different functions depending on their location.

These communities reduce water movement and erosion, enhance the deposit of sediment, serve as important carbon stores, and support wildlife.

- B. **Algal Beds** (Kelp Forests and Sargassum Beds) – These algal beds/forests are formed by large brown algae. In the temperate regions, kelp forests (mainly *Fucus*) form a distinct major marine community that supports a distinct population of marine organisms and its own food chain. In the tropics, the smaller brown alga, *Sargassum* can form extensive beds.
- C. **Seagrass Beds** – Seagrasses are flowering plants that are capable of binding sediments with their complex root systems. They form beds that can extend from the intertidal to subtidal areas. Like mangroves and salt marshes, they are important in carbon sequestration and as nurseries and habitats for fish and invertebrates.
- D. **Coral Reefs** – are tropical marine communities that are built mainly by scleractinian (hermatypic) corals of Phylum Cnidaria that possess symbiotic algae called zooxanthellae. The development of reefs is slow and is aided by other organisms like coralline algae and sponges. Reefs form complex structures that serve as habitats and nurseries for marine organisms.
- E. **Rocky Intertidal Communities** - sits at the juncture of crashing ocean waves and rocky shorelines. It can take the form of exposed rocky cliffs, boulder rubble, wave-pounded rocky shelves, and sheltered rocky shores. Organisms living in this ecosystem are faced with extreme levels of disturbance inherent in this environment, including submersion, exposure to air, and being pounded by surf.

Teacher Tip:

Students are more familiar with the term “seaweeds” but teachers are encouraged to use the term algae/alga.

Misconception:

Corals are non-living. Corals are invertebrates that belong to Phylum Cnidaria (not “Coelenterata”) as old references will show.

Note:

In the Philippines, intertidal rocky communities are not common although in some portions of islands can possess this community. The coast of Itbayat I and other islands in the Batanes group are mainly composed of this community.

- F. **Sandy Beach Communities** – These benthic marine communities are often thought of as barren since they are flat and seemingly uninhabited by organisms. Organisms that inhabit these communities usually burrow underneath the sand and are seldom. Examples of animals in sandy communities: Crustaceans like the sand hopper (left) usually found underneath decaying beach vegetation), mole crab (middle, “bakuku” in Cebuano) which burrows at the surf zone and ghost crab (right) that constructs deep burrows in the exposed sand.

(2) Oceanic Communities

- A. **Hydrothermal Vents** – Oceanic “hot springs” that are produced in the ocean due to underwater volcanies at spreading ridges and tectonic plate boundaries. These communities do not rely on photosynthesis as the base of the food web but rather chemosynthesis.
- B. **A whale fall** is the carcass of a cetacean that has fallen into the Bathyal or Abyssal zone on the ocean floor. As they are found at depths of 2,000 m or 6,600 ft, they create complex localized ecosystems that supply sustenance to deep-sea organisms for decades.
- C. **Cold seeps** are shallow areas on the ocean floor where gases percolate through underlying rock and sediment layers and emerge on the ocean bottom. The gases found in the seep are methane and sulfur-rich gases and sediments releasing petroleum.

Teacher Tip:

There are other oceanic communities (cold seeps, whale falls, Sargasso sea) that are present but its inclusion will depend on the teacher.

Misconception:

Ocean bottoms of the aphotic zone cannot support life since photosynthesis cannot occur. There are benthic communities in the ocean bottom that do not depend on photosynthesis.

(3) Terrestrial Biomes

Most of the classified biomes are identified by the dominant plants found in their communities.

The diversity of animal life and subdominant plant forms characteristic of each biome is generally controlled by abiotic environmental conditions and the productivity of the dominant vegetation.

- A. **Arctic and Alpine Tundra** - The geographical distribution of the tundra biome is largely poleward of 60° North latitude. The tundra biome is characterized by an absence of trees, the presence of dwarf plants, and a ground surface that is wet, spongy, and hummocky. Soils of this biome are usually permanently frozen (permafrost) starting at a depth of a few centimeters to >1m. The permafrost line is a physical barrier to plant root growth.

- B. **Boreal Coniferous Forest** his moist-cool, transcontinental coniferous forest, or TAIGA lies largely between the 45° and 57° North latitudes. Its climate is cool to cold with more precipitation than the tundra, occurring mainly in the summer because of mid-latitude cyclones. The predominant vegetation of boreal biome are needle-leaf evergreen variety tree species. The understory is relatively limited as a result of the low light penetration even during the spring and fall months.
- C. **Temperate Deciduous Forest** - As its name indicates, this biome is characterized by a moderate climate and deciduous trees. It once occupied much of the eastern half of the United States, central Europe, Korea, and China. This biome has been very extensively affected by human activity, and much of it has been converted into agricultural fields or urban developments. The understory of shrubs and herbs in a mature deciduous forest is typically well developed and richly diversified. The deciduous forest has four distinct seasons, spring, summer, autumn, and winter. In the autumn the leaves change color. During the winter months the trees lose their leaves.
- D. **Grassland** - In central North America are the grasslands, the tall grass prairie toward the east and the short grass prairie westward. In Europe and Asia some grasslands are called Steppes. In South America, grasslands are known as Pampas.
- E. **Desert** - In its most typical form, the desert consists of shrub-covered land where the plants are spatially quite dispersed. In general, the major desert biomes of the Earth are geographically found at between 25 to 40° North and South latitude, in the interiors of continents. Climatically, deserts are influenced by descending air currents which limit the formation of precipitation. Many desert areas have less than 250 millimeters of precipitation annually.
- F. **Chaparral** - Chaparral has a very specific spatial distribution. It is found in a narrow zone between 32 and 40° latitude North and South on the west coasts of the continents. This area has a dry climate because of the dominance of the subtropical high pressure zone during the fall, summer, and spring months. Precipitation falls mainly in the winter months. Annual averages range from about 300-750 mm and most of this rain falls in a period between 2-4 months. As a result of the climate, the vegetation that inhabits this biome exhibits a number of adaptations to withstand drought and fire.

- G. **Tropical savanna** - Tropical savannas are grasslands with scattered drought- resistant trees that generally do not exceed 10 m in height. Tree and shrub species in the savanna usually shed their leaves during the dry season. The savanna biome constitutes extensive areas in eastern Africa, South America, and Australia. Savannas also support the richest diversity of grazing mammals in the world.
- H. **Tropical rainforest** - Tropical rainforests occur in a broad zone outside the equator. Annual rainfall, which exceeds 2000-2250 mm, is generally evenly distributed throughout the year. Temperature and humidity are relatively high through the year. Flora is highly diverse: a square kilometer may contain as many as 100 different tree species as compared to 3-4 in the temperate zone. The various trees of the tropical rain forests are closely spaced together and form a thick continuous canopy some 25-35 m tall. Every so often this canopy is interrupted by the presence of very tall trees (up to 40 m) that have wide buttressed bases for support.

PRACTICE (60 MINS)

Connectivity

Class Discussion – Ask students how the terrestrial and marine environments are connected. Some guidelines are given below:

1. Life cycles of animals

Teacher Tip: Some animals migrate from rivers to sea / sea to rivers during their lifetime to reproduce. Some animals need to lay their eggs in water.

2. Decreased coral reef health due to siltation

Teacher Tip: Siltation is caused by soil that is loosened by heavy rainfall, gradually collected in streams and rivers until reaching the sea. The soil is loose since terrestrial vegetation is lacking to hold them. Trees with their deep roots would have allowed water to seep into the soil thus replenishing the water table. Reforestation should utilize native or endemic species that are found in our forests. Reforestation programs used non-native species (see reading assignment)

3. Pollution and Garbage

ENRICHMENT (30 MINS)

After the video showing, students are required to submit an essay discussing the roles of water quality include:

1. Transmission of Diseases
2. Red Tides
3. Fish kills due to oxygen depletion
4. Boracay and Coliform

To summarize and synthesize the learnings:

Video Show (<https://www.khanacademy.org/science/biology/crash-course-bio-ecology/crash-course-ecology-2/v/crash-course-ecology-10>)

Encourage students to watch the videos that synthesize the lesson on ecology:

- a. History of Life on Earth
- b. Population ecology: The Texas Mosquito Mystery
- c. Human Population Growth
- d. Community Ecology: Feel the Love
- e. Community Ecology II: Predators
- f. Ecological Succession: Change is Good
- g. Ecosystem Ecology: Links in the chain
- h. Hydrologic and Carbon Cycle: Always Recycle
- i. Nitrogen and Phosphorous Cycle: Always Recycle
- j. Effects of Humans on the Environment – Discusses deforestation, desertification, global warming, introduction of invasive or non-native species and overharvesting.
- k. Pollution – Discusses pollution caused by naturally occurring and synthetic compounds
- l. Conservation and Restoration Ecology

EVALUATION (10 MINS)

1. Deforestation happens most often in ____ biome.
 - (A) Taiga
 - (B) Tropical rainforest
 - (C) Tundra
 - (D) Desert

2. Which of these characterize a Tundra?
 - A. Sandy soil
 - B. Lots of trees
 - C. Permafrost
 - D. Standing water

3. ____ is characterized by lack of water in summer, seasonal temperature variations; maintained by periodic fires.
 - A. Tropical rainforest
 - B. Taiga
 - C. Arctic Tundra
 - D. Chaparral
 - E. (E) Desert

4. Endemic species are organisms that are ____.
 - A. Incapable of regulating their internal temperature.
 - B. Perfectly adapted to their habitat, example: fishes in water habitat.
 - C. Able to regulate their own body temperature and are capable to living in extreme conditions.
 - D. Organisms whose global distribution is not limited to specific localities.
 - E. Unique, native or found in some places only and not in others.

5. Seagrass beds are composed of ____.

- A. Terrestrial grasses
- B. Algae
- C. Flowering plants
- D. Mangrove trees

Reading Assignment

Students are required to submit a reaction paper to the following reference (Is the gov't reforestation program planting the right trees?)<http://www.rappler.com/nation/51200-national-greening-program-native-trees>

Journal

Students are to submit a week journal outlining their daily use/generation of the following:

- (A) Estimated amount of water used personally. Give details how water was used (bathing, washing, toilet breaks, brushing teeth and others).
- (B) (B) Estimated number of non-biodegradable garbage generated (food wrappers, plastic containers for food and water and others)

LEARNING COMPETENCY	ASSESSMENT TOOL	Exemplary (8-10)	Satisfactory (5-7)	Developing (3-4)	Beginning (1-2)
The learners describe how the different terrestrial and aquatic ecosystems are interlinked with one another S11/12-IVhj-30	Student participation (During lecture)	Student was able to answer the question without referring to his/her notes plus the follow-up question.	Student was able to answer the question without referring to his/her notes; Was not able to answer follow up question.	Student was able to answer the question but read from his/her notes.	(1) Student was not able to answer the question. (2) Student read from notes of his/her classmate..
	Student participation in Class Discussion	Student's input was significant & thought provoking, and showed deep awareness of issue(s) discussed.	Student's input was significant, and showed awareness of issue(s) discussed.	Student's input did not show awareness of issue(s) discussed.	Student did not participate in the discussion.
	Student Essay	Student submitted an impressive essay beyond the teacher's expectations.	Student submitted a comprehensive and well written essay.	Student submitted a written essay that lacked depth and preparation.	(1) Student submitted a poorly written essay. (2) Student did not submit an essay.
	Journal	The student's journal was detailed and comprehensive. He/she added details that beyond the requirements.	The student's journal was comprehensive and detailed.	The student's journal was complete but lacked details.	(1) The submitted journal was not complete and seems to be fabricated. (2) The student did not submit a journal.
	Examination	Obtained 90-100% correct answers in the exam	Obtained 70-80.99% correct answers in the exam	Obtained 50-69.99% correct answers in the exam	Obtained percentile <50% correct answers in the exam

Moh's Hardness Scale



(1) TALC



2) GYPSUM



(3) CALCITE



(4) FLOURITE



(5) APATITE



(6) FELDSPAR/ORTHOCLASE

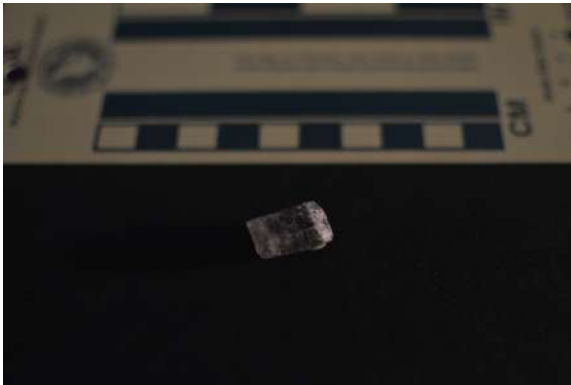
Moh's Hardness Scale



(7) QUARTZ



(8) TOPAZ



(9) CORUNDUM



(10) DIAMOND*

*<https://upload.wikimedia.org/wikipedia/commons/archive/b/bd/20140824201734%21DiamanteEZ.jpg>

Color Pages - Rocks and Minerals



HEMATITE WITH STREAK



PYRITE



PYROPHYLLITE



BAUXITE



GRANITE



RHYOLITE

Color Pages - Rocks and Minerals



DIORITE



ANDESITE



GABBRO



BASALT



STRATIFIED ROCK FORMATION



CONGLOMERATE

Color Pages - Rocks and Minerals



BRECCIA



CLAYSTONE



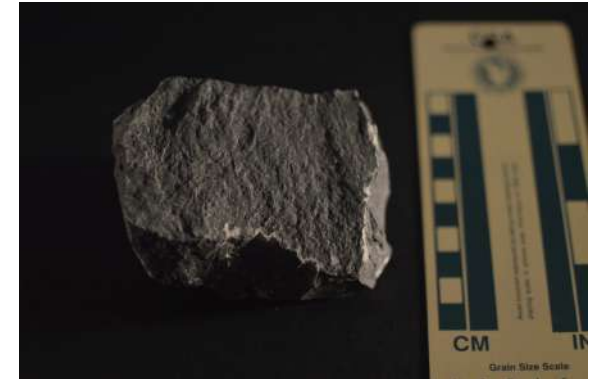
COAL



LIMESTONE



COQUINA



HORNFELS

Color Pages - Rocks and Minerals



MARBLE



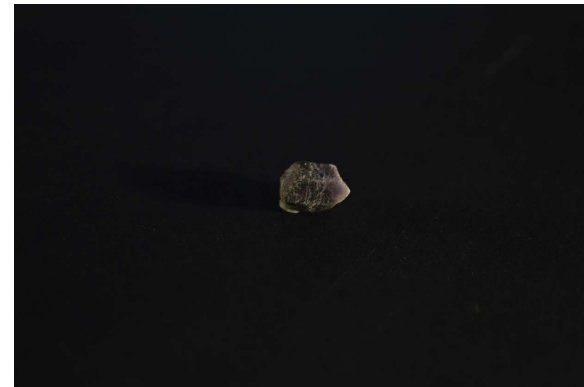
SLATE



PHYLLITE



SCHIST



GNEISS

Color Pages - Fossils



AMMONITE



BRACHIOPHOD



COPROLITE
(FOSSILIZED EXCREMENT)



FOSSILIZED FISH



FOSSILIZED LEAF



FOSSILIZED SHARK'S TOOTH

Color Pages - Fossils



PETRIFIED WOOD



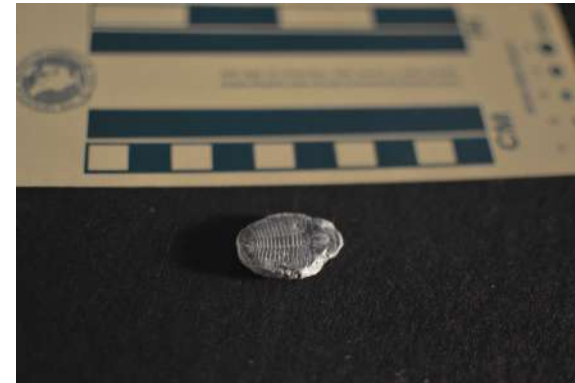
HEART URCHIN



MEGALODON TOOTH



STEGODON TUSK



TRILOBYTE

Biographical Notes

IVAN MARCELO A. DUKA

Team Leader - Life Science

Prof. Ivan Marcelo A. Duka is an Associate Professor 5 and the College Secretary of the College of Arts and Sciences at the University of the Philippines Los Banos. He has been teaching at the university various courses, such as Biology 1 and 2, Molecular Biology, Evolutionary Biology, Cell Biology and Genetics for 40 years.

He finished his Master of Science in Genetics from the University of the Philippines Los Banos, and his Bachelor's Degree in Biology, major in Zoology, in the same university. He also earned a Cell Biology Apprentice Degree from the University of Wales College of Cardiff, United Kingdom. He received numerous grants and fellowships, such as the AIDAB Fellowship Award in Sydney, Australia; and the British Council Fellowship to the University of Wales. He also wrote various papers, articles, books, laboratory manuals, and other teaching materials focusing on Biotechnology, Molecular Biology, Immunology, Recombinant DNA Techniques, Physiology, and Genetic Engineering.

Prof. Duka is also a Board Member of the Philippine Society for Biochemistry and Molecular Biology, a Subject Matter Specialist of the Learning Resource Centre for Biology Tutorials and Biology Summer Bridge Course, and a member of the UPLB University Council. He is also primarily responsible for assisting incoming university instructors by providing them necessary mentorship in classroom management and curriculum development.

LEOPOLDO DE SILVA, PH.D.

Team Leader - Earth Science

Dr. Leopoldo P. De Silva, Jr. is a Geologist and a Professor at the National Institute of Geological Science where he has been teaching for over 10 years now. Dr. De Silva has worked as a contract field geologist supervising both greenfield and brownfield exploration at the Bowen Basin, Queensland. He has also worked as a project geologist for exploration work on both Styx Basin and the Galilee Basin. He has experience with Micromine, AcQuire, LogCheck, Mapinfo, and Vulcan Software packages.

He received his doctorate in Geosciences and master's degree in Geology at the Tsukuba University in Tsukuba, Japan. He earned another master's degree and his bachelor's degree in Geology at the University of the Philippines Diliman. He is an active member of different organizations in the country and abroad, such as the Australian Institute of Geoscientists, the Geological Society of Australia, and the University of the Philippines Geological Association.

CRISTINA T. REMOTIGUE

Writer - Earth Science

Cristina T. Remotigue finished her bachelor's degree in Geology, master's degree in Geology, and her doctoral degree in Geology at the National Institute of Geological Sciences at the University of the Philippines Diliman. She also acquired units in Education, and her master's degree in Special Education at the University of the Philippines Diliman. She is both a licensed teacher and a licensed geologist. She served as lecturer at the Ateneo de Cagayan, a project coordinator for a project under the consortium of Netherlands Red Cross, an instructor at the Mindanao University of Science and Technology, and a grade 11 science teacher at the Manila Waldorf School. She has also co-authored numerous publications and other professional papers.

ERNESTO A. DIZON JR.

Writer - Earth Science

Ernesto A. Dizon, Jr. is a professional Geologist who has over 14 years of experience working in the mineral industry, primarily in the gold-base metal deposits, thermal, and coking coal deposits. He has worked as Vice President for Exploration and Drilling for the Galeo Equipment Corporation. Mr. Dizon also practiced his profession in the Philippines and different countries such as Kyrgyzstan, Australia, Cambodia, Guyana, and Vietnam. He finished his bachelor's degree in Geology through a DOST scholarship at the University of the Philippines Diliman.

ZORAIDA S. DIZON

Writer - Earth Science

Zoraida S. Dizon served as the Geoscience Operator and Marine Seismic Processor at the CGGVeritas International SA, where she assisted in the creation of project documentation such as weekly reports in addition to actively managing onboard resources to optimize efficiency of production. She also served as the Mudlogging Geologist at the Geoservices Ltd. Aberdeen at the United Kingdom, where she was responsible for equipment and sensor maintenance at the UK sector of the North Sea. She finished her bachelor's degree in Geology at the University of the Philippines Diliman, and she became a licensed geologist in 2002.

EDDIE L. LISTANCO, D. SC.

Writer - Earth Science

Dr. Eddie Listanco is a professional Geologist and a retired professor at the University of the Philippines Diliman where he taught for 28 years. He earned his doctorate and master's degrees in Geology at the University of Tokyo, Tokyo, Japan and completed his bachelor's degree in Geology at the University of the Philippines Diliman. Over the years, Dr. Listanco has published significant number of national and international journals, monographs, laboratory manuals, field guidebooks, and books on volcano geology, volcano geochemistry, and geology education. Dr. Listanco is an active member of organizations such as the National Research Council of the Philippines, the Volcanological Society of Japan, and the International Association of Volcanology and Chemistry of the Earth's Interior.

AILEEN C. DELA CRUZ*Writer - Life Science*

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