DEPARTMENT OF EDUCATION

GRADE 12

BIOLOGY

MODULE 1

ECOLOGY

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PRIVATE MAIL BAG, P.O. WAIGANI, NCD
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Writer
Leoninen Correa

Content Editors
Science Department
Subject Review Committee

Language Editor
Dr. Steven Winduo

Course Format Editor
Anna Liza Cale

GRADE 12

BIOLOGY

MODULE I

ECOLOGY

IN THIS MODULE YOU WILL LEARN ABOUT:

11.1.1: BIOMES AND HABITAT

11.1.2: INTERACTIONS

11.1.3: HUMAN IMPACTS ON THE ENVIRONMENT

Acknowledgements

We acknowledge the contributions of all Lower and Upper Secondary teachers, who in one way or another helped to develop this Course.

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DIANA TEIT AKIS
PRINCIPAL

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SECRETARY'S MESSAGE

Achieving a better future by individual students and their families, communities or the nation as a whole, depends on the kind of curriculum and the way it is delivered.

This course is a part of the new Flexible, Open and Distance Education curriculum. The learning outcomes are student-centred and allows for them to be demonstrated and assessed.

It maintains the rationale, goals, aims and principles of the national curriculum and identifies the knowledge, skills, attitudes and values that students should achieve.

This is a provision by Flexible, Open and Distance Education as an alternative pathway of formal education.

The course promotes Papua New Guinea values and beliefs which are found in our Constitution, Government Policies and Reports. It is developed in line with the National Education Plan (2005 - 2014) and addresses an increase in the number of school leavers affected by the lack of access into secondary and higher educational institutions.

Flexible, Open and Distance Education curriculum is guided by the Department of Education's Mission which is fivefold:

- To facilitate and promote the integral development of every individual
- To develop and encourage an education system satisfies the requirements of Papua New Guinea and its people
- To establish, preserve and improve standards of education throughout Papua New Guinea
- To make the benefits of such education available as widely as possible to all of the people
- To make the education accessible to the poor and physically, mentally and socially handicapped as well as to those who are educationally disadvantaged.

The college is enhanced to provide alternative and comparable pathways for students and adults to complete their education through a one system, many pathways and same outcomes.

It is our vision that Papua New Guineans' harness all appropriate and affordable technologies to pursue this program.

I commend all those teachers, curriculum writers, university lecturers and many others who have contributed in developing this course.

UKE KOMBRA, PhD
Secretary for Education

MODULE 12.1 ECOLOGY

Introduction

This module of biology is on ecology. **Biology** in general is the study of living things, and **ecology** is the study of how these living things interact with each other and their environment. From your lower sciences you have studied some of the different organisms and their easily observable characteristics. You learned about those organisms that you find just around you and other places in the country.

A simple ecosystem

In addition, you learned about organisms other than plants and animals. Some of these consist only of a single cell while others have many. You may also have a chance to look at organisms that are so small and can be seen only with the microscope.

This module will introduce you to the concept of **biodiversity**, specifically the variety of organisms living on Earth. It will give you the chance to learn about the fascinating world of ecosystems. An **ecosystem** is a community of living organisms and the physical environment with which they interact. It will let you discover uses of some, not just as food but also in medicine, agriculture, industries and the ecosystems where they are present. In addition, you will know about the harmful effects of some to other organisms. This topic is very important today because ecosystems are being seriously threatened by human activity.

Most importantly, the study of this module hopes to encourage you to start or continue protecting and conserving your community's biodiversity for future generations. You will apply your knowledge by examining a case study. At the end of this module, you will use the decision-making model to propose a course of action regarding an important environmental issue.

Learning Outcomes

After going through this module, you are expected to:

- describe and differentiate species, population, community, habitat and niche
- state and describe common abiotic and biotic factors of major biomes
- discuss and describe the effects of rainfall, temperature, humidity, light intensity on plant and animal life of an ecosystem or environment.
- identify the types of behavioral, morphological and physiological adaptations of organisms in terrestrial environments.
- list and describe the biotic and abiotic factors of the aquatic environment
- describe and explain food chains, food webs, producers, consumers and decomposers, autotrophs, heterotrophs, herbivores, carnivores, omnivores, predators, parasites and saprophytes with examples from various biomes
- define food chain, food web, producers, consumers, decomposers, autotrophs, heterotrophs, herbivores, carnivores, omnivores, predators, parasites, saprophytes
- describe the effect of biomagnification and eutrophication along a food chain with examples from aquatic environment
- define and explain succession, primary and secondary succession
- list the human activities that have undesirable effects on the environment
- list the measures taken in the management of development activities

Time Frame

Suggested allotment time: **10 weeks**

If you set an average of 3 hours per day, you should be able to complete the module comfortably by the end of the assigned week. Try to do all the learning activities and compare your answers with the ones provided at the end of the module. If you do not get a particular exercise right in the first attempt, you should not get discouraged but instead, go back and attempt it again. If you still do not get it right after several attempts then you should seek help from your friend or even your tutor.

DO NOT LEAVE ANY QUESTION UNANSWERED

Terminology

Abiotic factors	These are the non-living things that have an impact of organisms. The non-living components of an ecosystem, like rocks, soil, temperature and weather.
Anthropogenic	(adj) Caused or produced by humans.
Autotrophs	Primary producers.
Biomes	Specified areas, for example tundra, pine forests, woodlands, deciduous forests, temperate rainforests, tropical rainforests, savannah, grassland and deserts. The same biomes have similar climate and similar vegetation types although the major species which constitute these communities vary within biomes depending upon altitude, species diversity and the distance from their major source of colonists.
Biosphere	The part of the earth sphere where life exists.
Biotic	The living components of an ecosystem, like plants, animal, bacteria and other organisms.
Brush	Wild vegetation, generally larger than grass but smaller than trees.
Brush land	An area covered with brush growth.
Brush fire	A fire involving low-growing plants (as scrub and brush).
Carnivores	Animals that eat other animals for food.
Clear felling	Cutting down of virtually all trees.
Climatic Factors	Physical factors such as temperature, light, wind, water and air currents and humidity.
Community	Many populations of organisms living together in one place.
Consumers	Organisms that eat other organisms for energy.
Coexistence	Organisms living together and sharing a habitat.

Crop rotation	Method of cultivation when a piece of land is divided into a number of plots and the same piece of land is used over and over again by moving the crops around.
Curb	An enclosing framework or border.
Desiccate	To become thoroughly dried or dried up.
Decomposers	Organisms (bacteria and fungi) that break down decaying matter for energy and nutrients.
Denitrification	Reduction of soil nitrates into gaseous nitrogen.
Ecological niche	Sometimes referred to as the ecological situation in which organisms are able to exist.
Ecological succession	Refers to a series of development whereby specific groups of living organisms colonises an ecosystem at any one time over a period of time until the ecosystem becomes stable.
Edaphic factors	The influence of soil on organism distribution.
Ecology	The study of how organisms interact with their environment and with other organisms.
Ecosystem	All of the living and non-living components of an environment that interact to function as a system.
Energy pyramid	A diagram showing the flow of energy through a food chain.
Environment	All the conditions necessary for an organism to live and survive.
Habitat	A place where organisms live.
Herbivores	Animals that feed on plants for food.
Heterotrophs	Consumers that feed on either plants or other animals for food.
Humidity	The amount of water vapour in the atmosphere expressed as a percentage of the total capacity at a particular temperature.

Global warming	Warming of the earth's atmosphere to higher temperatures than considered normal. This is considered to be due to excess gases such as carbon dioxide and methane.
Greenhouse effect	The natural heating of the earth's atmosphere and trapping of heat due to the conversion of ultraviolet light to infrared within the earth's atmosphere.
Habitat	The natural environment where a particular species or community of animals lives; the physical environment that surrounds and influences them.
Incineration	A waste treatment technology that involves burning commercial, residential and hazardous waste.
Lacunae	A small space or opening.
Landfill	A site for the disposal of waste materials by burial and is the oldest form of waste treatment.
Leguminous plants	Plants that usually have swellings on their roots. Examples are peanuts and beans which are good sources of organic nitrogen.
Methemoglobinemia	A form of disease which develops when toxic substances enter the blood and prevents its formal function.
Nitrification	The conversion of ammonium salts to nitrates.
Nitrogen fixation	Process by which nitrogen is added to the soil from the free gaseous nitrogen in the air.
Nitrogen-fixing bacteria	Bacteria that can make proteins, using carbohydrates and gaseous nitrogen in the air.
Nodules	Swellings containing nitrogen-fixing bacteria in the roots of leguminous plants.
Omnivore	An animal that eats both plants and animals.
Organism	A living thing.
Parasites	Either plants or animals that live off other organisms.

Pollutant(s)	Any substance, as certain chemicals or waste products, that renders the air, soil, water, or other natural resource harmful or unsuitable for a specific purpose**.**
Producers	Organisms that use inorganic material such as sunlight or chemical compounds to produce their own food.
Primary producer	The organisms in an ecosystem that convert the sun's energy and inorganic material.
Primary Consumers	Herbivorous organisms that eat producers.
Primary succession	Occurs when the first organisms invade and colonise a barren area.
Secondary Consumers	Carnivores that eat herbivores.
Vernalization	The act or process of hastening the flowering and fruiting of plants by treating seeds, bulbs, or seedlings so as to induce a shortening of the vegetative period.
Ten Percent Rule	Only about 10 percent of the energy available in one trophic level is available to organisms in the next higher trophic level.
Toxins	Any poison produced by an organism, characterised by antigenicity in certain animals and high molecular weight.
Trophic Levels	The feeding levels in a food chain.

12.1.1 Biomes and Habitats

What is Ecology?
The word **eco** comes from the Greek word **oikos**, which means house. Scientists who study ecology are called **ecologists.**

The branch of biology that deals with the study of the interactions among organisms and with their **environment** is known as **ecology**. It explains how living organisms affect each other and the world they live in.

Ecology and Environment

We tend to use the terms **ecology** and **environment** to mean the same. But we must understand that there is a difference between these two terms. Ecology limits itself to connections, processes and phenomena occurring in the **natural** world. Environment means 'me and my surroundings' and hence not only includes the natural part of the surroundings, but also all those elements that have been created by **humans**.

The essence of ecology lies in the study of the togetherness of everything, plants, animals, microorganisms and their environment. Ecology can, at times be very complex due to the large number of interconnections in the natural world.

One way to make the study of the natural world easier is to understand it in smaller units. So let us look at ecology from the point of view of 'levels (hierarchy) of organization'.

Levels of organization
This hierarchical theory of levels of organisation provides a convenient framework for dealing with complex situations, because each of these levels has some special features, and hence the study of ecology, in parts, at these levels, becomes easier.

Let us understand these levels one by one.

Ecologists have organised the interactions an organism takes part in into different levels according to complexity.

1. **Organism**
   Organism is any form of **life**. An individual living organism that is made of cells, uses energy, reproduces, responds, grows, and develops. An organism can also be thought of as an individual member of a species. A wide range of variety of organisms is present on the earth—from single celled amoeba to huge sharks, from microscopic blue green algae to massive banyan trees.
2. **Species**
   Group of organisms that resemble one another in appearance, behaviour, chemistry and genetic structure form a species. Organisms of the same species can breed with one another and produce fertile offspring under natural conditions.

For instance, all human beings (*Homo sapiens*) resemble one another in their body structure, body systems and they all have similar genetic structure. They are thus grouped together under the species *sapiens*.

3. **Population**

A **group of organisms, all of the same species**, which interbreed and live in the same given area at the same given time. Can you find out the human population of your area?

4. **Community**

All the populations in an ecosystem. Populations of various species occupying a particular area and interacting with each other make up a community. Here by community we mean an 'ecological community' (so do not confuse it with a social community).

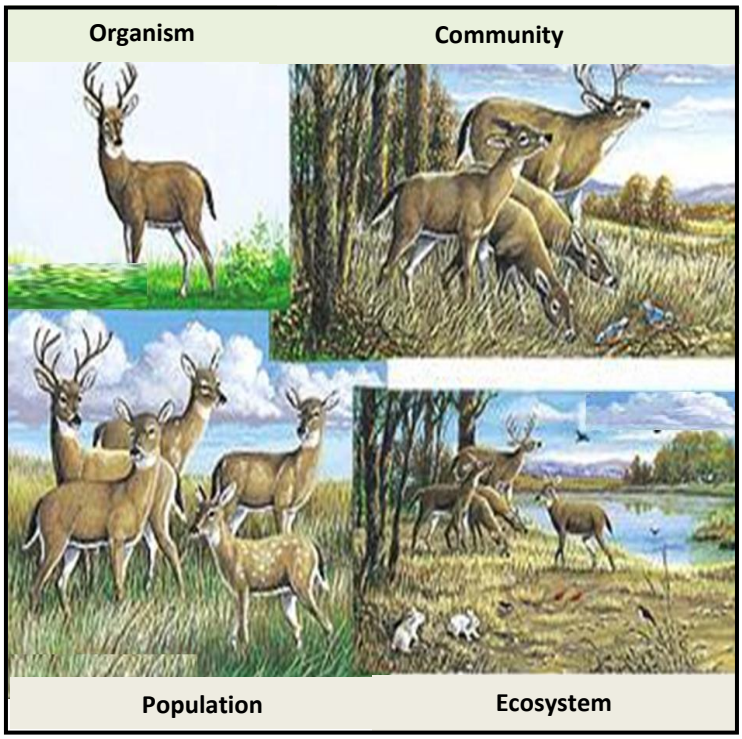
For instance, when we say 'the community of the rainforest, we refer to all the various populations, could be the teak tree population, the wallaby, tree kangaroo, lion, tiger, leopard, deer, cattle, and the populations of a variety of grass species, of all kinds of birds, plants, animals, and microorganisms present there. Thus, a community comprises several species interacting with each other.

5. **Ecosystem**

An **ecosystem** is a **community of organisms** involved in a dynamic network of biological, chemical and physical interactions between themselves and with the nonliving components. Such interactions sustain the system and allow it to respond to changing conditions.

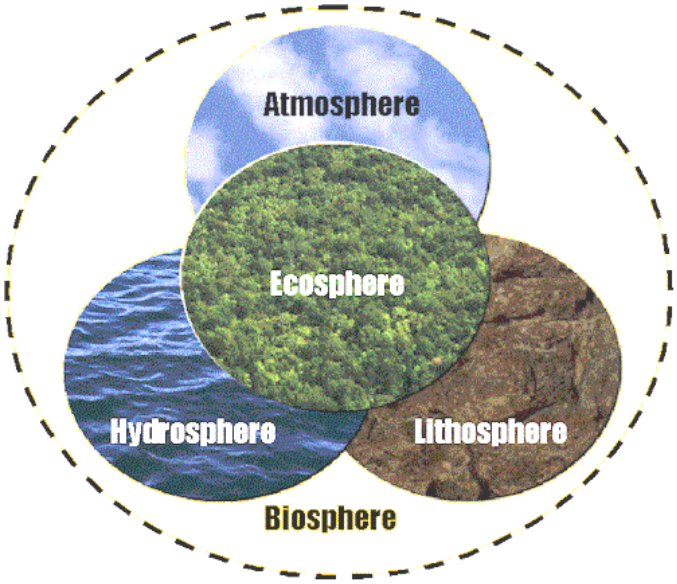
Thus an **ecosystem includes the community, the non-living components and their interactions.**

Can you create such a hierarchical picture for a particular ecosystem that you know of?



The sum total of all the ecosystems on planet Earth is called the **biosphere**, which includes all the earth's living organisms interacting with the physical environment as a whole to maintain a steady-state ecosystem.

Look at the diagram on the right. Together the zones atmosphere, lithosphere, ecosphere, hydrosphere make up the **biosphere.**

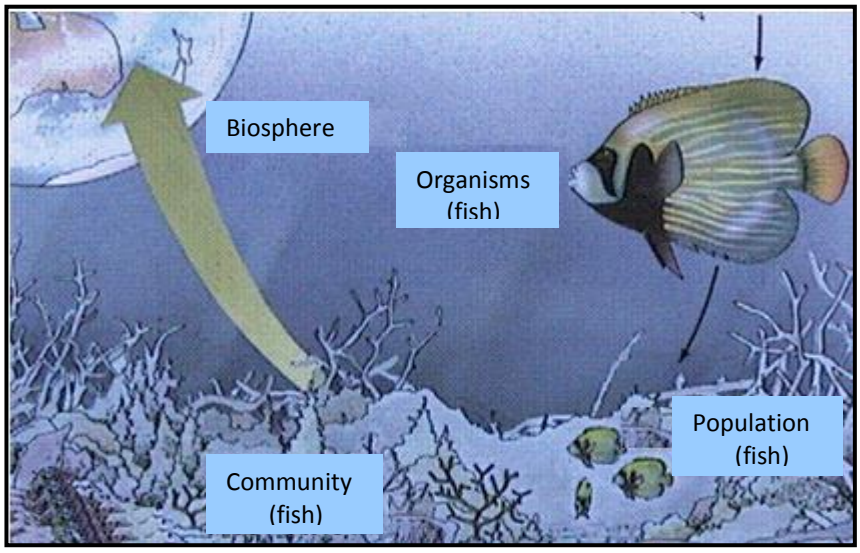


Biosphere can be defined as the sum total of all organisms and their habitats**.**
Habitat is the place where a plant or animal lives. So its boundaries are defined by where organisms live and interact with each other and their **environment.**
Niche is an organism's total way of life. It is the way in which an organism adapts to its habitat and satisfies its needs.

The biosphere extends only a few kilometers below the surface of the Earth, and only a few kilometers into the atmosphere.

Life is not the same all over the biosphere.

The Earth has many different environments, varying in temperature, moisture, light, and many other factors.



Biosphere under the water

Each of these habitats has distinct life forms living in it, forming complex communities of interdependent organisms.

Life changes from place to place mainly because of climatic changes.

The sun's angle plays a major role in creating Earth's climate zones, due to the tilt of the Earth on its axis. The sun strikes the area around the equator at a near-vertical angle, delivering substantial solar heat energy to this region. Closer to the poles, the sun strikes the Earth at a much shallower angle, resulting in less solar heat gain compared to the tropical zone. Prevailing winds and ocean currents then transport this solar heat energy throughout the globe. Factors such as elevation and proximity to the coast help to explain climate variations within a climate zone.

What are earth's three major climate zones?

Polar zone
The polar climate zones fill the areas within the Arctic and Antarctic Circles, extending from 66.5 degrees north and south latitude to the poles. Characterised by a short, cool summer and long, bitterly cold winter, the polar zone features frequent snowfall, particularly during the winter months.

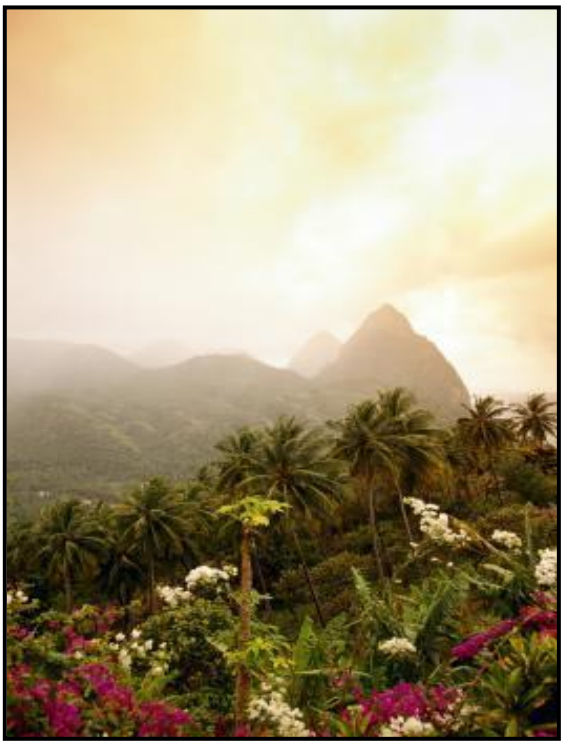
The far northern portions of Canada, Europe and Russia fall within this climate zone. Farther north and south, the ice caps that make up Greenland and Antarctica represent a sub-zone of the polar climate region known as the ice cap zone. Within the ice caps, temperatures rarely, if ever, rise above freezing, even during the warmest months of the years.

Temperate zone
Extending from the southern edge of the Arctic Circle to the Tropic of Cancer in the northern hemisphere, and the northern edge of the Antarctic Circle to the Tropic of Capricorn in the southern hemisphere, the temperate climate zone falls between 23.5 degrees and 66.5 degrees north and south latitudes. Temperate climate zones experience warm to hot summers and cool winters, with the greatest temperature variations throughout the year of any climate zone. Climate within the temperate regions ranges from the cold, snowy winters of New England to the balmy, moderate weather associated with the Mediterranean or Southern California. Much of the United States, Europe and the southern half of South America fall within this climate zone.

Tropical zone
The tropical climate zone stretches from the Tropic of Cancer at 23.5 degrees north latitude to the Tropic of Capricorn at 23.5 degrees south latitude, with the equator centered within this zone.

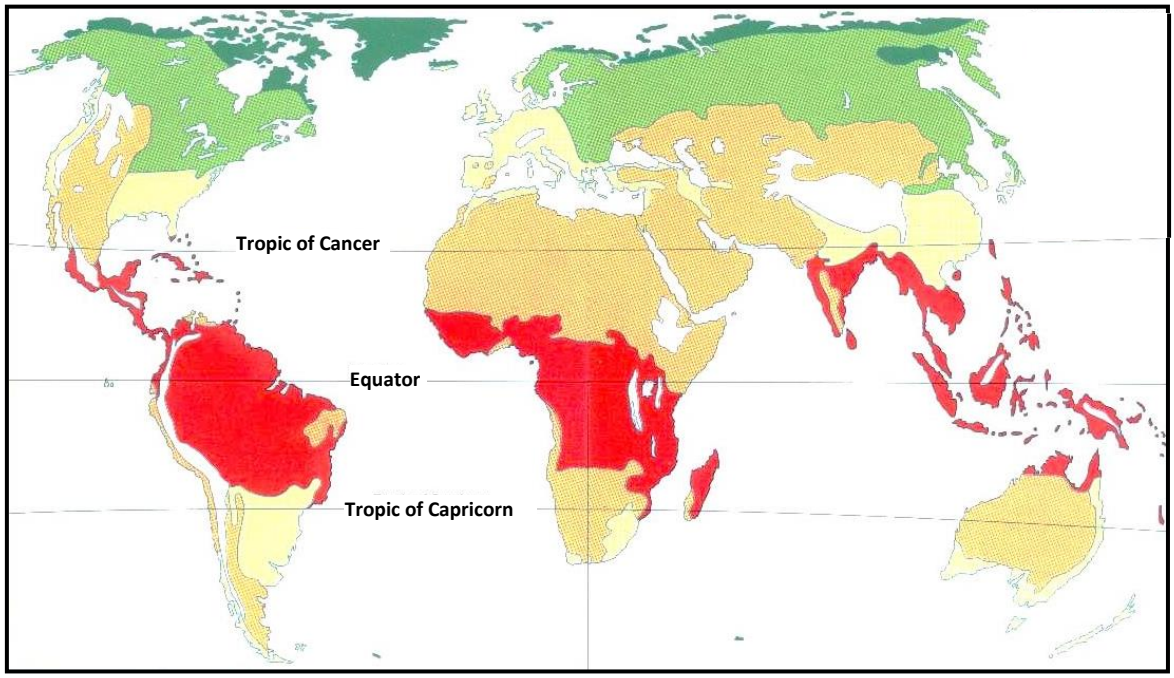
Climate within the tropical zone varies from the tropical wet regions of the rainforest, to the drier arid and semi-arid climate of north Africa or central Australia.

Within the tropical wet zone, the weather remains hot and muggy, with frequent rainfall and little temperature variation. The arid and semi-arid regions experience wet, warm summers and cooler, drier winters, with much greater temperature variation than the tropical wet zone.



Tropical wet conditions near the Equator allow lush vegetation and flowers to thrive.

CLIMATE ZONE MAP



Tropical climate (hot and humid)

Dry Climate (desert and steppe)

Mild Climate (warm and humid)

Continental climate (cold and humid)

Polar Climate (very cold and dry)

Mountain Areas altitude affects climate

As a system, the functions of the biosphere are fascinating and extremely complex. Because our planet has many diverse plants, animals, and environments, ecologists tend to study smaller areas called **ecosystems.** They have approximately the same climate.

Can you recall the definition of 'ecosystem'?

Each ecosystem has a definite structure and components, and that each component part of the system has a definite role to play in the functioning of the ecosystem.

At first glance, an ecosystem may appear simple, even boring. Upon closer examination, you will notice the wide variety of living organisms present in the ecosystem. Many factors become apparent, as do the interactions of organisms with one another, and with the physical environment. Ecology truly is the study of the "houses" of Earth

Ecosystem is a system of living organisms that interact with each other and with the physical world.

Have you ever wondered, what is present in a pond, or besides the tall giant trees, what more exists in a forest?

Can you explain why the type of soil, its moisture content could determine what grows on the piece of land, or how population of cassowary and wild pigs in a forest affect its soil quality?

Terrestrial ecosystem

Pond ecosystem

Ecosystems are more than just the organisms they contain. Geography, weather, climate and geologic factors also influence the interactions within an ecosystem.

Factors Influencing Plant and Animal Life

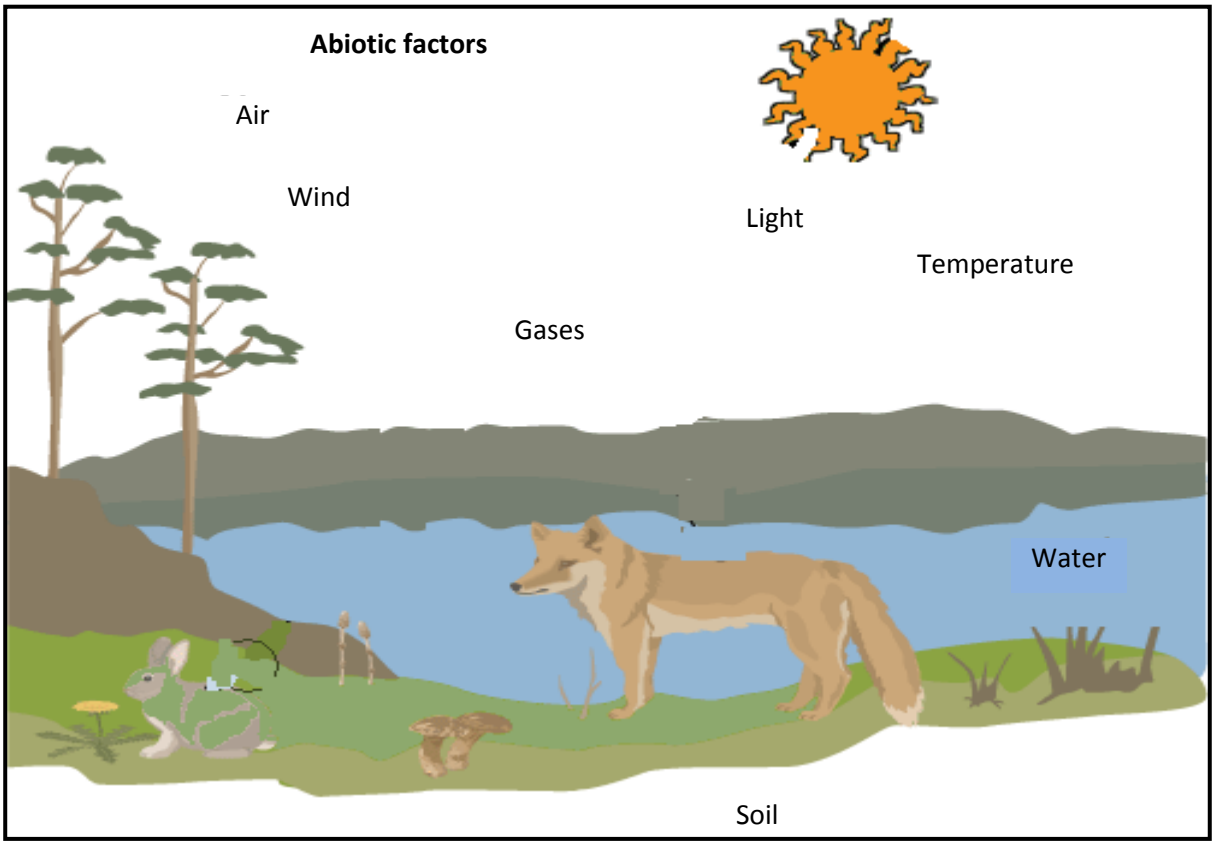
There are two major components in the ecosystem that influence plant and animal life.

A. **Abiotic factors** are the non-living components of a habitat which include amount of water and oxygen, temperature, amount of sunlight and water pressure.

   Also include light, acidity, radiation, humidity, temperature and all organic and inorganic components of the ecosystem. The quantity of the abiotic components present in the ecosystem is known as **'the standing stage'**.

List of abiotic factors

The abiotic factors play a major role in the environment. The list of abiotic factors are clouds, weather, latitude, temperature, oxygen, salinity, soil (edaphic factors), air, water, sunlight, humidity, topography, soil, pH and atmospheric gases.



The abiotic factors in an ecosystem are grouped into soil (edaphic), air, topography, meteorology, availability of water and quality of water. The meteorological factors are temperature, wind, sun, humidity and precipitation. The activities and growth of plants and animals are a result of several of these abiotic factors.

Let us read through the list of abiotic factors and how these factors affect the ecosystem and their interactions with the biotic factors.

1. **Soil (edaphic factors)**

Soil texture

The texture of the soil is variable from particles like clay to larger particles like sand. Sandy soils are suitable for growing plants and are well aerated and are easy to cultivate. They cannot retain much water and contain few nutrients required for plant growth.

Soil air are the spaces between the soil particles where it is not filled with soil water. The soil air determines the firmness of the soil.

Temperature of soil is an important factor, temperature of soil below 30cm is said to be constant but there are seasonal variations. The decaying caused by decay-causing microorganisms is low at lower temperature.

Soil water is classified into three types: capillary water, hygroscopic water and gravitational water.

Soil pH of the soil affects the biological activity in the soil and certain mineral availability. The pH influences the growth and development of plants. The organisms

and the decaying matter in the soil is known as **soil solution** and it increases the fertility of the soil.

2. **Light** is the primary source of energy to almost all ecosystems. The light energy is used by the heterotrophs to manufacture food by the process of photosynthesis by combining together other inorganic substances. The factors of light like its quality, intensity and the length of the light period play a vital role in an ecosystem.

   The quality of light affects the aquatic ecosystems, the blue and red light is absorbed here and it does not penetrate deep into the water. Some algae have specialised pigments that absorbs the other colors of light.

   The intensity of light depends upon the latitude and season of the year. During the period from March to September the Southern Hemisphere receives less than 12 hours of sunlight while it receives more than 12 hours of sunlight during the rest of the year.

   Some plants flower only during a certain time of the year. One of the factors is due to the length of dark period. Depending on the intensity of light the plants are classified as short-day plants (Examples are Chrysanthemum species, Datura stramonium.) Long-day plants (Examples are spinach, barley, wheat, radish, clover) Day-neutral plants (Examples tomato, maize)

3. **Temperature** influences the distribution of plants and animals. The occurrence of frost is important to determine the distribution of plants as most of the plants cannot prevent freezing of their tissues. Below are a few examples of the effects of temperature in plants and animals:

   - The blooming of flowers either in the day or night is due to the temperature difference between day and night.
   - Some biennial plants germinate during spring or summer this is known as **vernalization**.
   - Some fruit trees require cold temperature so as to blossom in the spring.
   - Animals have a clear distinction between being cold blooded or warm blooded.
   - Seasonal migration is seen in some animals**.**

4. **Water**

   Habitats of animals and plants vary widely from aquatic environments to the dry deserts. Water is essential for life and all the biotic components of the ecosystem are directly dependent on water for survival.

   Based upon their water requirements plants are classified as:

   - Hydrophytes (Example - water lilies)
   - Mesophytes (Example - sweet pea, roses)
   - Xerophytes (Example - cacti, succulent plants)

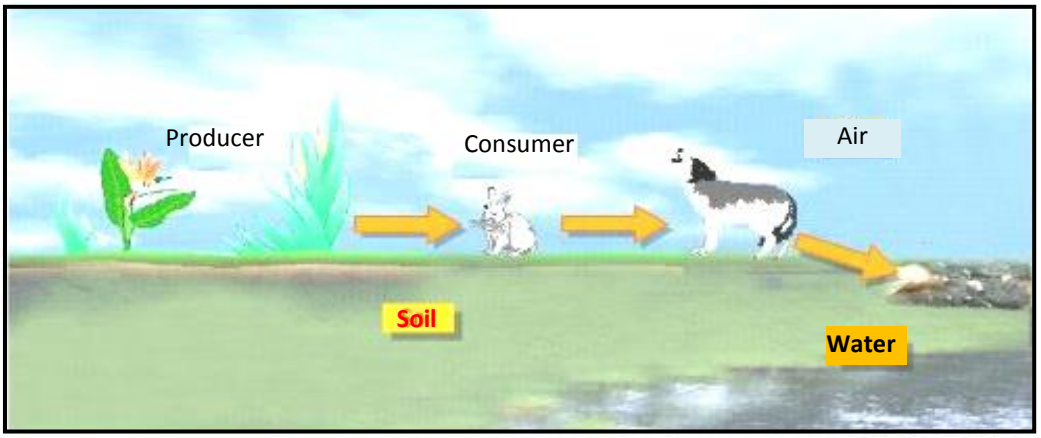
Land animals are prone to desiccation and these animals show various types of adaptations to the environment. Some of the adaptations seen in terrestrial animals are:

- body covering which limits loss of water**.**
- some animals have sweat glands which are used as cooling devices.
- the tissues of some animals like camel are tolerant to water loss.
- some insects are said to absorb water from water vapor directly from the atmosphere.

- **Atmospheric gases** like oxygen, nitrogen and carbon dioxide:
  - All organisms require oxygen for respiration.
  - Carbon dioxide is used by green plants to make food by the process of photosynthesis.
  - Nitrogen is necessary for all plants and atmospheric nitrogen is fixed by nitrogen fixing bacteria through the action of lightning.

B**.** **Biotic factors** are all the living organisms that inhabit an environment. All organisms depend on others directly or indirectly for food, shelter, reproduction, or protection.

A biotic factor is a living organism that affects another organism in its ecosystem. Examples include plants and animals that the organism consumes as food, and animals that consume the organism as shown on the diagram below.



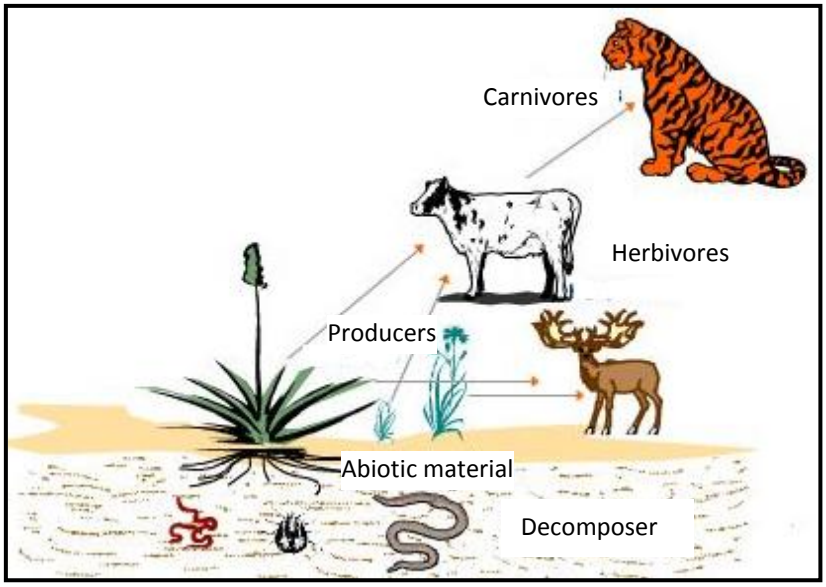
Grassland ecosystem showing its components

While abiotic factors determine where a particular species is able to live, biotic factors often determine the species' success. For example, while deer are able to survive the abiotic conditions in dense forests, they are more abundant in open woodlands. This is where they obtain preferred food species and can watch for predators.

Many key biotic factors involve interactions between individuals.
Individuals are often in competition with members of their own species and with other species. They compete for limited resources, such as food, light, space, and mates.

Can you identify the biotic factors in the diagram on the right?

By now, you have already learned about a number of the ways that life has helped to create and maintain the conditions that support its existence.



Biotic factors in a food cycle

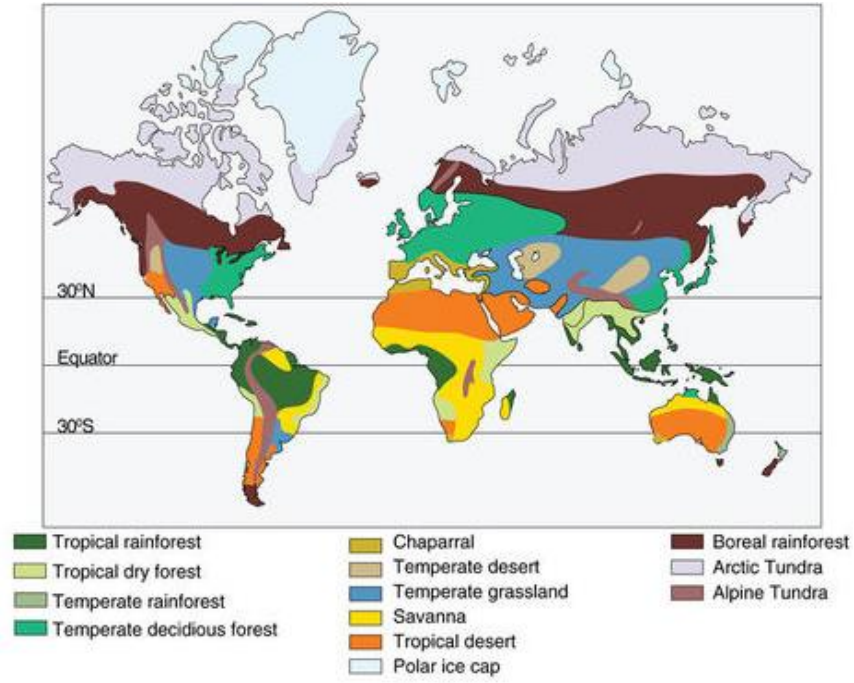
Forest versus desert, what explains these differences?

If you look at these two pictures, you will see very few similarities. The picture on the left shows a desert in Africa. The picture on the right shows a rainforest in Australia. The desert does not have any visible plants, whereas the rainforest is densely packed with trees. Do they have different climates? Does one get more rain than the other?

Climate is one of the main factors that determine what living things will be found in any given environment. Large areas on the earth with similar climatic features and supporting similar vegetation types and animals are known as **biomes**. Different biomes have characteristic sets of factors which are fairly uniform throughout.

A complex community of plants and animals in a region and a climate is called a biome. A biome is a collection of related ecosystems.

Study the world map below using the geographical descriptions of the location of five important biomes on our next topic.



The following descriptions on this topic summarise the basic features and geographical descriptions of major biomes. As you read about each biome, think about how its biodiversity and types of plants and animals relate to its climate.

For example, why do you think there are no amphibians or reptiles in tundra biomes? (Hint: Amphibians and reptiles cannot maintain a constant body temperature. Instead, they have about the same temperature as their surroundings.)

Some of the biomes on Earth include the following:

A. Terrestrial environment

1. **Desert**

   A very dry, either hot or cold, found predominantly to the north and south of the tropical band located mainly between latitudes 15°N and 45°N and in the southern hemisphere, between latitudes 15°S and 30°S restricted mainly to the western side of continents.

Desert in Southern California United States

Deserts are ecosystems with hardy inhabitants, able to survive in an environment that receives less than 25cm of rainfall annually.

Cactus

The desert is home to plants that lie dormant until it rains, and then they bloom and spread their seeds, which then lie dormant until the next rainfall. It is also home to plants capable of storing their own water, such as cactus.

Different plants have their own way to preserve and get water. Some plants have developed tap roots. These tap roots can extend to thirty meters below the surface to draw water out of the water table.

This cactus displays few desert adaptations: it has spines rather than leaves and it stores water in its stem.

Other plants have shallow roots to catch water as soon as it lands. Desert sand is well drained and water does not sit around on top. This means water can soak into the ground very fast.

Some plants such as the spines or fur trees reduce the heat by facing leaves directly up or down to minimize surface area hit by the sun so less water is evaporated.

Many desert animals survive the searing heat by burrowing or living in caves. These animals are largely nocturnal, staying underground during the heat of the day and foraging for food at night when it is cool.

2. **Tropical Rainforest**

Warm and very wet. Found in a band on either side of the equator to latitudes 15^{o}N and 15^{o}S. Occupying entirely the island of New Guinea, Indonesia and Malaysia much of South East Asia, and western equatorial Africa and also the Amazon region.

Tropical rain forests are home to a great diversity of animals. The climate is hot with excessive rainfall, and vegetation grows in several layers from the forest floor to the canopy.Papua New Guinea (PNG) possesses one of the planet's largest remaining tropical rainforest.

Tropical rainforest in Papua New Guinea

At least seventy-five percent of its original forest cover is still standing, occupying vast, biologically rich tracts over 100,000 square miles in all. Its forests provide the habitat for about 200 species of mammals, 20,000 species of plants, 1,500 species of trees and 750 species of birds, half of which are endemic to the island. It has been estimated that between 5 and 7% of the known species in the world live in PNG.

Rare plants and animals like the largest orchid, largest butterfly, the longest lizard, largest pigeon and the smallest parrot ever registered live in these forests.

Tropical rainforests receive 160 to 400 inches of rainfall per year and the rain can be very heavy. To adapt to this, most leaves of trees have pointed tips and are very slippery. This is to help the rain glide off the leaves so they do not cause damage. Also, this keeps them dry which prevents mould or mildew from forming, in the humid environment. This helps them to survive in the rainforests.

The trees in the rainforest weigh hundreds of tonnes and are some of the tallest living structures on earth but they have roots in very thin soil. Whenever it rains, which is very often, the soil is washed away leaving even thinner soil.

To anchor the tree and prevent it falling over, they have huge buttresses roots that spread to a distance of 9 meters. They come in various shapes and sizes but all have the same purpose, which is to stabilise the tree.

Buttress roots

3. **Taiga or Coniferous Forest**

Cool and dry, with coniferous trees. Found in the northern temperate regions of Europe, Asia and North America.

Predominantly between 45^{o}N and 70^{o}N. Coastal coniferous and temperate deciduous forests flank the west and east coasts of the U.S., respectively. They experience four seasons, and only moderate rainfall. The northern Canadian forests are predominately coniferous and experience long sub-arctic winters.

The picture above shows what the majority of the coniferous forest looks like.

4. **Chaparral or scrub**

Coastal area with hot, dry summers and mild, cool, rainy winters. The temperature is usually mild, however, it can get very hot or nearly freezing. The temperature range is between 30° and 100° Fahrenheit.

Chaparral in Southern California, United States

This biome only gets about 10 – 17 inches of rain per year and most of it comes in the winter. Because of the long period of dryness in the summer, only plants with hard leaves can survive, such as scrub oaks, chamiso shrubs, pines, cork and olive trees.

Many leaves are also hairy so they can collect the moisture out of the air and use it. Chaparral is one of the most fire-prone plant communities in North America because of heat and tropical storms.

Droughts are also very common. Some plants have adapted even to the fires. Their seeds will lie dormant until there is a fire. Their seed casings will crack and the seed will sprout only. The chaparral biome has many different types of terrain. Some examples are flat plains, rocky hills and mountain slopes.

Some of the adaptations of the chaparral fauna are that the animals do not require much water. The animals have learned to live in their biome by being nocturnal and are usually small. The animals are all mainly grassland and desert types adapted to hot, dry weather. Animals have adapted to this sparse and rough terrain by becoming agile climbers, foraging over larger areas and varying their diet to include the often scrubby brush lands

5. Grassland

Windy, partly dry sea of grass with few trees, including tropical savanna, prairie, steppe, pampas. Found throughout the Indian sub-continent, and surrounding the areas of tropical rain forest in equatorial Africa, South America and Australia.

In a grassland ecosystem, many stands of trees are eradicated by brush fires and dry periods (though single trees and a few tree stands do survive). Fire is a common occurrence in grassland ecosystems. Because of this, the grassland biome is characterised by short or tall grasses and some small shrubs, but no trees.

Plants in the grassland biome have adapted to annual fire events. For example, though the parts of plants that are aboveground, such as stems and leaves, are destroyed by fire, their root systems are able to sprout following the fire event. In addition, some plants produce seeds that require a fire event to begin the germination process.

Given the lack of precipitation, many plants in the grassland biome have extensive root systems that absorb water at and below the ground surface. Other plants have long tap roots that reach into the soil to find water sources deep below the surface. These extensive root systems also ensure that grazing animals are unable to pull the plants out from their roots, meaning the plants can re-sprout after the animal feeds on the aboveground portions (stems, seeds, leaves) of the plant.

However, the grasslands, as their name indicates, receive sufficient precipitation to sustain different varieties of grasses.

Animals that live in grassland ecosystems exhibit a number of different adaptations. For example, many animals that are found in grassland biomes are grazers such as pronghorn antelope.

Grassland ecosystem

Other animals, such as prairie dogs, live in underground burrows that allow them to spend time in a cool environment rather than in the hot and windy conditions aboveground.

Today, many grass lands are endangered because farmers allow their herds of animals to overgraze. The grasslands are subdivided into tropical grasslands (also known as the savannahs) temperate grasslands, like the prairies of the Midwest in the United States; and the polar grasslands like the northern Canadian tundra.

6. Tundra

Cool, treeless, and dry. Found between the coniferous forest. Found between the coniferous forest and the permanent ice-cap of the North polar region, usually between latitudes 60°N and 75°N**.** The term “tundra” most commonly denotes polar areas, but at lower latitudes, tundra-like communities known as alpine tundra may be found at high elevations.

As with deserts, a harsh environment characterises ecosystems in the tundra. In the snow-covered, windswept, treeless tundra, the soil is frozen year-round, a condition known as **permafrost**. During the brief spring and summer, snows melt, producing shallow ponds which attract migrating waterfowl.

You would think that plants would never live or survive in this biome, but the answer is quite a surprise. There is low diversity in organisms that live here, but many still flourish.

Many lichens, mosses, and small shrubs flourish in the arctic tundra. The plants that live in the harsh permafrost soil usually adapt to the weather by being short and grouped together to resist winds and to be protected. The growing season in the tundra is short and lasts up to 60 days.

Tundra plants get their energy from the sun through photosynthesis like all other plants, but have adapted to low temperatures and low light intensities. Compared to plants in other biomes they use a minimal amount of energy.

These tundra plants are low-growing.

You may think that the tundra is too cold for animals, but guess what, it is not. There are actually animals that live in this harsh biome! You might find lemmings, caribou, and arctic hares in the tundra.

These animals seem pretty nice, but can you guess which of the largest and most dangerous animal lives in there? The Polar bear.

Alpine tundra in the Alps Mountains of Switzerland in Europe

A polar bear mom and her cubs exploring the tundra in Kaktovik, Alaska.

B. Aquatic environments

Freshwater environment

1. Freshwater

Freshwater biomes are large communities of plants and animals which survive on water with less than 1% salt concentration. They are very important for survival on Earth.

Types of freshwater biomes include ponds, lakes, streams, rivers, and some wetlands.

(Wetlands are not always considered freshwater biomes because they usually have too high salt content.)

Freshwater biomes are found all around the world. They have many seasons. A single pond during the summer season could be up to 39 degrees Fahrenheit on the bottom and 72 degrees Fahrenheit on the top.

This same pond could be 39 degrees Fahrenheit on the bottom and 32 degrees Fahrenheit on top in the winter season. The climates usually average 39 degrees Fahrenheit to 70 degrees Fahrenheit.

Freshwater plants have adapted various types of leaves, depending on where they are located on the plant. Underwater leaves are very thin in order to be able to absorb as much diffused light as possible.

In some plants, they are so thin they appear as strands of algae. Floating leaves are also common. These leaves are broad and have lacunae that contain gas to offer the leaves buoyancy. Willow trees adapt long, narrow leaves with tapered tips.

They grow above water but drape down so that their tips are sometimes submerged. Their shape allows them to be moved freely by running water, but also keeps them from tearing during this continuous act.

Freshwater environments require animals to adapt to low-water or low-oxygen environments, such as in the case of shallow river beds. All of the more than 400 species of freshwater crayfish are adapted to tolerate low oxygen conditions and exposure to air. Behaviourally, they are also adapted to live for extended periods in burrow systems under mud in case there is an absence of surface water.

2. **Marine water**

Marine regions cover about three quarters (3/4) of the Earth's surface and include oceans, coral reefs, and estuaries. Marine algae supply much of the world's oxygen supply and take in a huge amount of atmospheric carbon dioxide. The evaporation of the seawater provides rainwater for the land.

Most animals and plants find a way to breathe underwater and take in the salt water. Animals have adapted and grown gills. Gills allow them to breathe in the ocean water. Most animals have sleek bodies to swim through water, the sleek bodies help cut down friction on the animal. Also, some animals have their eyes on the side of their heads to see predators all around them.

Fish have fins and those help they swim faster; fish also are certain colours to camouflage themselves. Most mammals in the ocean, such as whales have blubber to provide warmth. These are all just basic adaptations for fish; there are many specific ones for the conditions the animal or plant lives in.

A specific adaptation would be the clown fish. They live in sea anemones, which are like plants. Their relationship with the anemone has been going on for a very long time, and over time the clown fish has adapted. Anemones have stingers for protection and clown fish have adapted to them by producing mucus that protects them from the anemones stings.

Marine plants and algae attach firmly to rocks and other things, so waves do not wash them away. Certain seaweeds are tough and leathery, which protects them from being torn or dried out by the sun.

3. **Estuaries**

Estuaries are areas where freshwater streams or rivers merge with the ocean. This mixing of waters with different salt concentrations creates a very interesting and unique ecosystem.

Microflora like algae, and macroflora, such as seaweeds, marsh grasses, and mangrove trees (only in the tropics), can be found here. Estuaries support a diverse fauna, including a variety of worms, oysters, crabs, and waterfowl.

Estuaries are areas between the moving and still waters. They also offer a habitat to many different plants and animals, including types of coral reefs, fish, shellfish, and birds. Some of animals in estuaries have a very unique ability to survive in both fresh water and salt water.

Coral reef in Papua New Guinea

4. **Mangrove** refers to both a habitat in the intertidal zone and to the specialized, salt-tolerant trees and shrubs that grow there. Approximately 75 percent of coasts located between 25° N and 25° S support this vegetation type. Mangroves grow in both wet and dry climates within this latitudinal belt.

Mangrove trees

In desert areas the mangroves are low shrubs, but in tropical rainforest areas they can be trees 120 ft or more in height. All have evolved ways to tolerate waterlogged soils and high salinity. To overcome the constraints of a saturated substrate, many produce some kind of aerial root (pneumatophore).

Black mangroves produce thin, vertical projections from their roots that are completely underwater when the tide is in, but exposed to the air at low tide. Red mangroves have prop roots arching from their trunks to the ground. In both structures, pores in the surface allow air to penetrate to the underground ground roots during low water levels.

Strategies to deal with high salinity are similar to those found among salt marsh plants. Some, such as Rhizophora, prevent salt uptake by their roots.

Others, such as Avicennia, allow salt to enter the roots but have salt glands on their leaves to get rid the plants of excess salt. A few species allow salt to accumulate in barks and leaves and then shed these tissues to eliminate excess salt.

5. **Wetlands** are areas of standing water that support aquatic plants. Marshes, swamps, and bogs are all considered wetlands.

Plant species that adapt to the very moist and humid conditions are called **hydrophytes**. These include pond lilies, cattails, sedges, tamarack, and black spruce. Marsh flora also includes such species as cypress and gum.

Wetlands have the highest species diversity of all ecosystems. Many species of amphibians, reptiles, birds (such as ducks and waders), and furbearers can be found in wetlands. Wetlands are not considered freshwater ecosystems as there are some, such as salt marshes, that have high salt concentrations; these support different species of animals, such as shrimp, shellfish, and various grasses.

It is now time for you to complete Learning Activity 1. Remember, learning activities are not sent in for assessment. However, this learning activity will help you complete Assignment 1 (which you will send in for assessment).

Learning Activity 1

20 minutes

A. Define

(i) Ecology

_____

(ii) Ecologists

_____

(ii) Ecosystem

_____

B. Match the items in the left column to their level of organization in the right by writing the letter of your choice on the space provided for.

_____ 1.	Kingfishers	a.	Community
_____ 2.	Animals and plants in Nature's Park	b.	Ecosystem
_____ 3.	Your friend's cat	c.	Species
_____ 4.	An estuary	d.	Population
_____ 5.	Sheep in Adventure Park	e.	Organism

Thank you for completing your Learning Activity 1. Check your work. Answers are at the end of this module.

It is now time for you to complete Assignment 1 in your Assessment Book 1 before going on to the next topic.

12.1.2: Interactions

Feeding Relationships- Interactions between Organisms

Organisms of different species in a community do not stay in isolation from each other, and hence community ecology is concerned with the variety of interactions that take place between the various species. When any two organisms have some activities or requirements in common, they interact with each other.

Species are closely linked, forming networked systems. In fact, constant interactions occur within (intra-specific) and between (interspecific) different species. Such interactions occur principally for habitat, food, defense, and reproduction.

These interactions include the following.

1. **Competition**

   In most communities, each organism faces competition from one or more organisms for limited resources.

   Competition is where one organism hinders another organism's access to some resource, say food, water, and shelter irrespective of the fact that the resource is abundant or scarce. For instance, some coral animals kill other nearby corals by poisoning them.

   Competition can also be when two competing organisms have equal access to a particular resource, but differ in how quickly or efficiently they exploit it. In this way, one organism gets more of the resource, thereby hampering the growth, reproduction and survival of the other.

   This kind of competition is usually exhibited only when a resource is scarce. For instance grasses thrive better in deserts than other plants because their root systems are more efficient in absorbing more water in a short time than those of other plant species.

2. **Mutualism**

   It is the type of interaction, where both the interacting species benefit from each other.

   A common example is the interaction between flowers and insects, where the flower is benefited by being pollinated by the insect as shown in the diagram on the right.

   In some cases species involved cannot survive without each other. Example, fungus known as lichen gets its food from algae, while the algae gets protection as shown on the right. If separated, neither can survive.

3. **Predation** is the consumption of one individual (prey) by another (predator). For instance, lion preys on deer, or an eagle feeds on fish in a pond.

Eagle feeds on fish

Lion preys on deer

4. **Commensalism**

It is a cooperative relationship where one partner gains from the relationship while the other is neither benefitted nor harmed.

Examples can be found in dense forests as shown on the right, where sunlight does not reach the ground in sufficient quantity, orchids grow on other tree species. The orchid is benefited by getting sufficient light, but the tree is neither benefited nor harmed.

Orchids getting light but tree
Is neither benefited nor harmed

5. **Parasitism**

This is a one way relationship where the parasite gains and the host is adversely affected.

Parasites are usually smaller than their hosts. They do not immediately kill or consume the hosts but only derive their nutrition from them, examples ticks attach themselves to dogs and suck the blood. Similarly tapeworms are found in the human intestine.

Ticks attach themselves to dogs and suck the blood

Why should organisms interact with each other?

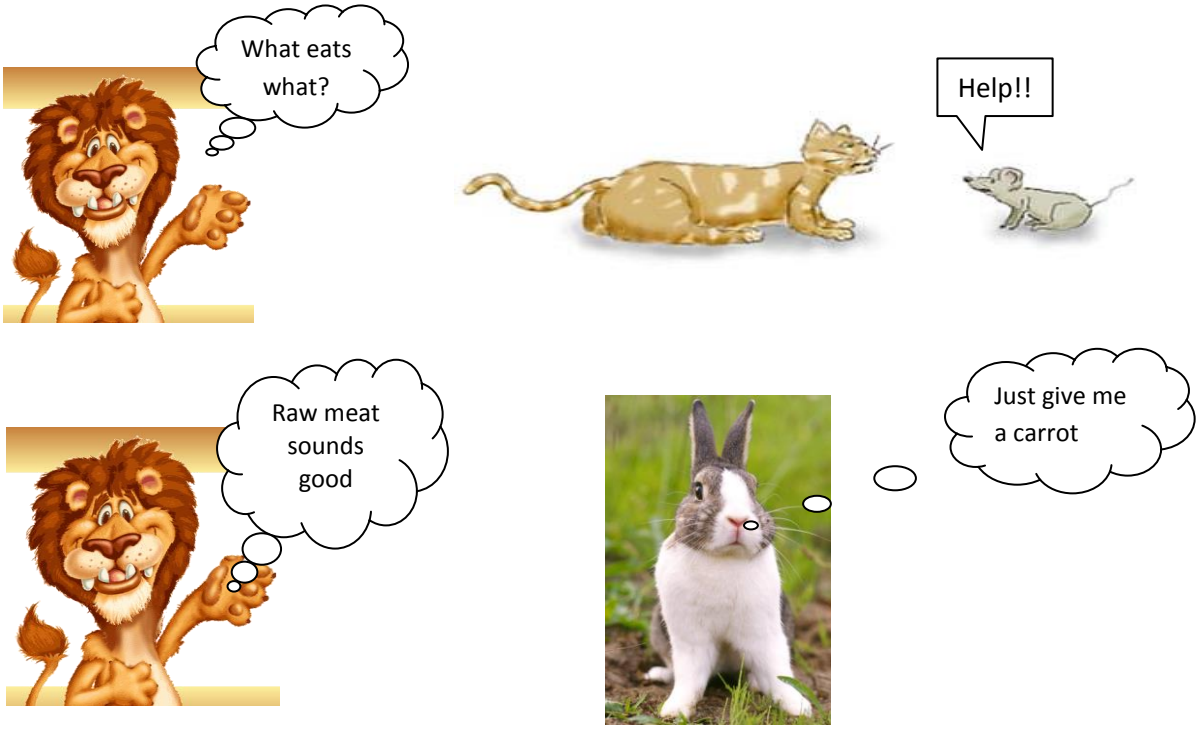
All living things depend on each other as a food source for energy.

Every activity that organisms do in ecosystems such as breathing, moving, running, burrowing, growing requires energy. The flow of energy is the most important factor that controls what kinds of organisms live in an ecosystem. All these organisms need energy to sustain life.

How is energy transferred from one organism to another?

All animals eat other organisms, or at least secretions of other organisms, to acquire energy. In our next topic we will discuss the organisms that make the flow of energy possible in ecosystems through **food chains** and **food webs**.

What do animals eat?



To have a clear understanding of how energy flows from one organism to another through food chains and food webs, let us analyse the living components (biotic factors) of ecosystem. It is important to note that organisms play different roles in a certain ecosystem.

Living organisms (biotic components) in an ecosystem can be classified as either **producers** or **consumers**, depending on how they get their food.

1. **Producers or autotrophs** produce their own food by using simple inorganic food by the process of **photosynthesis**. An organism that gets its energy from an abiotic source is called a **producer**. Plants get their energy from sunlight so they are producers.

2. **Consumers or heterotrophs** are organisms that depend on other organism for energy. They directly or indirectly depend on food provided by producers. They are classified into four types based on their food habits.

What do plants need?

Herbivores are plant eating animals like the rabbit that feed directly on carrot. Other examples are grasshoppers, butterflies, rabbits, and desert tortoises, feed at the trophic level of the **primary consumer**.

Carnivores are animals that only eat other animals thus they are also known as meat eaters. They feed on herbivores, the primary consumer so they are known as **secondary consumers**, but can also feed at the trophic levels of tertiary, or quaternary consumer or even higher if a particular food chain is long enough. Animals that only eat other animals, like scorpions, snakes, spiders, hawks, owls, and lions are carnivores.

Omnivores eat both plants and animals. Examples are pigs, rats, cockroaches and humans. They can potentially feed at any of the consumer trophic levels.

Decomposers (detritivores) are organisms that feed on waste products or dead organic material. Detritivores can take dead organic material and bring the stored energy back into the food chain. They can be thought of as the recyclers of the ecosystem. They digest the complex organic molecules in dead organic matter (detritus) into simpler inorganic compounds. They absorb the soluble nutrients as their food. Some examples are bacteria, fungi, and mites.

It is now time for you to complete Learning Activity 2. Remember, learning activities are not sent in for assessment. However, this learning activity will help you complete Practical Activity 1.2 (which you will send in for assessment).

Learning Activity 2

40 minutes

Food Chain

How do you identify the components of a food chain in an ecosystem?

Objectives:

After performing this activity, you should be able to:

1. distinguish between producers and consumers.
2. analyze the transfer of energy from one organism to another.
3. construct a food chain in a given ecosystem.

Materials:

- Diagrams and illustrations of components in an ecosystem.
- Activity sheet(your course book)

Procedure:

1. Read an article about “The Sonoran Desert in the Southwestern United States” on the next page.
2. Answer the questions that follow, on the space provided.

The Sonoran Desert

by Joshua Anderson

The Sonoran Desert in the Southwestern United States may seem like a desolate place, but looks can be deceiving, because a wide array of wildlife can be found in this very dry environment. You might wonder how animals can make a living in the desert - after all, what is there for them to eat? In the Sonoran Desert is the prickly pear cactus. Many different animals eat the fruit of the prickly pear cactus, including Harris's antelope squirrel. In this case, the squirrel gets its energy from the fruit of the prickly pear cactus. In turn, the squirrel can be eaten by another organism, the diamondback rattlesnake, and the rattlesnake can then be eaten by a roadrunner? and no, that is not a mistake. In the Sonoran Desert, roadrunners are deadly organisms that will commonly pick up rattlesnakes by the tail and smash their head repeatedly onto the ground in a whip-like fashion. Once the rattlesnake is dead, the roadrunner will swallow it whole. In cases where the rattlesnake is too large to swallow all at once, the roadrunner will partially swallow the snake, with its tail still hanging out of its beak. As the first parts of the snake are digested, the roadrunner will then continue to swallow the rest of the snake. The roadrunner itself can also be eaten. Red-tailed hawk. You thought I was going to say a coyote, didn't you? Well, it turns out that, much like in the cartoon, adult roadrunners are just too fast for a coyote to catch, although coyotes will eat roadrunner eggs and chicks. In any case, the Red-tailed hawk is one of the few animals able to catch an adult roadrunner and make a meal of it.

Answer the following questions:

1. Name the organisms found in the surrounding area of Sonoran Desert?

   _____

   _____

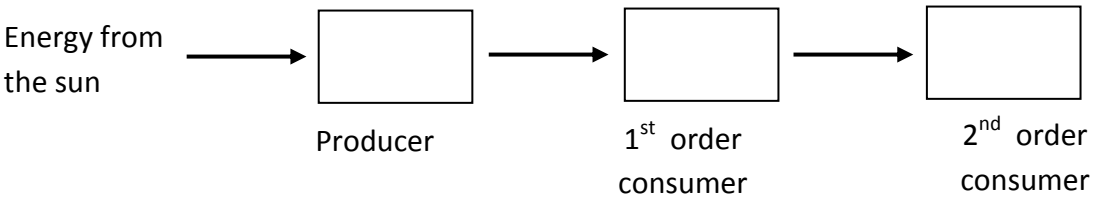
2. What group/s of organisms is considered as producers? _____

3. What part of the prickly pear cactus served as food for the squirrel? _____

4. Divide the organisms into the following categories as shown in the table below:

Producer/s	1st Order Consumer/s	2nd Order Consumer/s

5. Based on the Table in question 4, construct a food chain with at least 3 organisms representing the producer, 1st order consumer and 2nd order consumer.



6. You have just analyzed the transfer of energy by categorizing the organisms according to their trophic level. In your own words, describe a food chain.

_____

_____

Thank you for completing your Learning Activity 2. Check your work. Answers are at the end of this module.

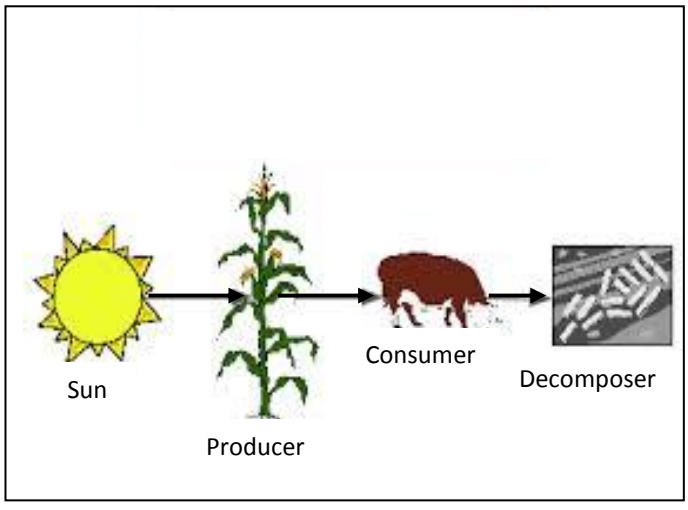
Trophic Levels of Feeding Relationships in Organisms

Energy flow

The flow of energy is the most important factor that controls what kinds of organisms live in an ecosystem. In our next topic, you will learn how organisms obtain energy. This includes the discussion on how producers and consumers make possible the flow of energy through ecosystems through food chains and food webs.

All energy from plants and animals whether living or dead originates from the sun. Most plants make much more food each day than they need.

Plants may convert excess glucose into starch. Starch may then be stored in other parts of the plants such as roots and fruits. When people and other organisms eat plants, chemical energy from food substances is transferred to their bodies for their survival. This means that energy flows from one organism to another in the ecosystem. Hence the **feeding relationship** is a good point to study ecosystem.



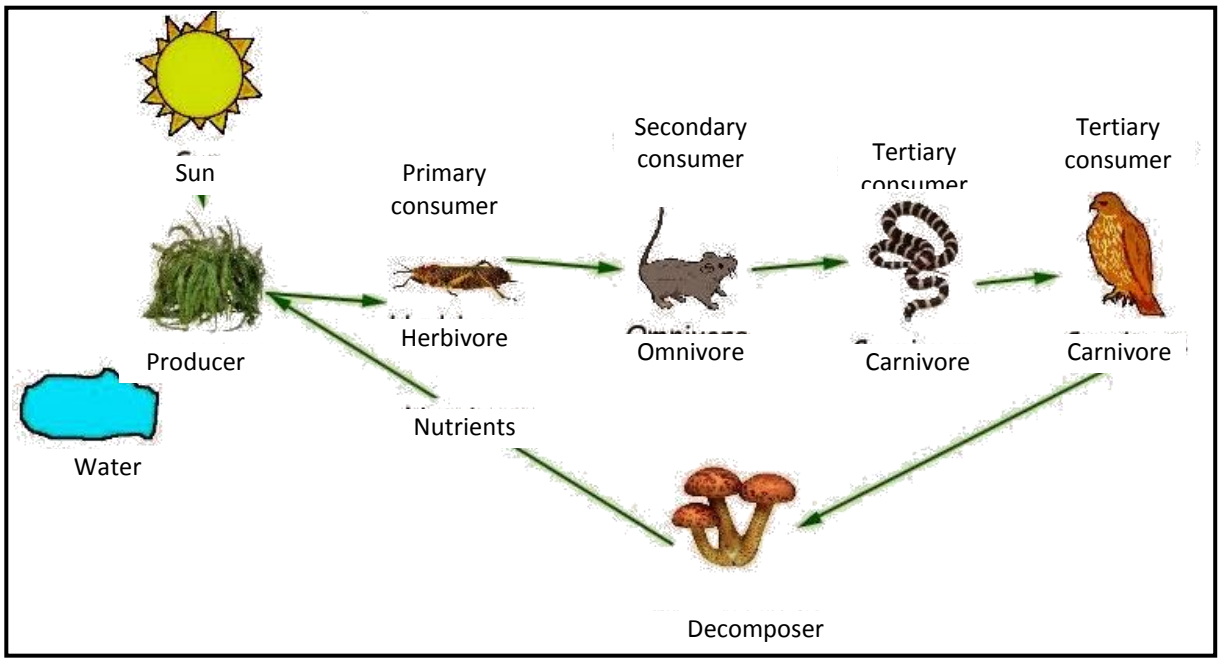
Energy flow in a simple food chain

Food chains

A food chain shows the feeding relationship between different living things in a particular environment or habitat.

It represents a series of events in which food and energy are transferred from one organism in an ecosystem to another.

Food chains show how energy is passed from the sun to producers, from producers to consumers, and from consumers to decomposers. Often, a plant will begin a food chain because it can make its own food using energy from the sun



Temperate Deciduous Forest Food Chain

The concept of food chain looks very simple looking at the previous pictures and diagrams, but in reality more complex feeding relationships occur. Come to think of it, how many different animals eat grass?

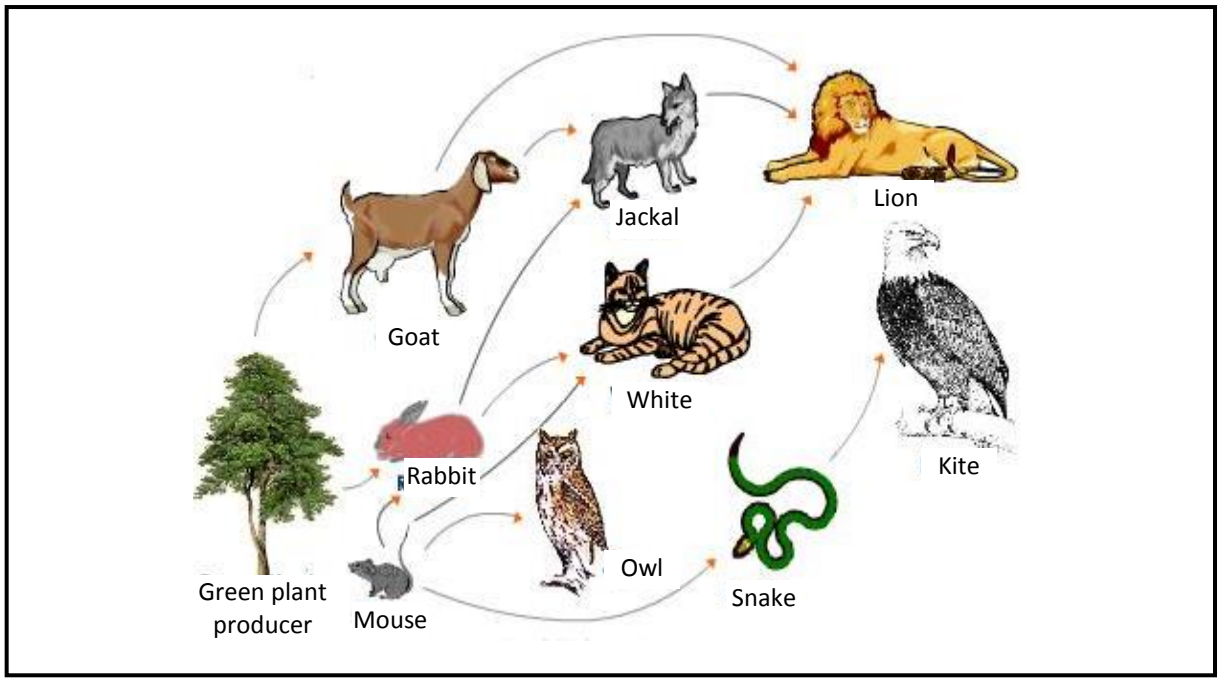
Observations have shown that animal species cannot feed entirely on one species. Example, grasshoppers feed on taro leaves and aibika.

Willie wagtails and lizards prey on grasshoppers, crows feed on lizards while snakes might feed on birds. You could not find simple independent food chain but two or more and complex food chains are interconnected that look like a web.

Food webs

Food chains may be interconnected to form a food web. For example, one kind of food may be eaten by several consumers. Or several foods, may be eaten by one consumer.

Study the diagram of food web in forest on the next page. Can you identify how many animals eat the producer? How many food chains can you identify?



Food web in a forest

Energy flow through a food web

Now, let us look at how much energy actually flows through the food web. We know that plants and animals use energy in their daily activities, and we also know that plants and animals store energy within their tissues.

When organisms eat, they take in matter as well as energy into their bodies. For example, when you eat chicken, the flesh of the chicken containing nutrients and energy enters your body. You use the nutrients and energy to build muscles and other parts of your body and to perform various activities. So, how much energy did you use, and how much is stored?

The answer actually varies based on many factors, such as the type of organism, but there are rules that we can use to estimate how much energy is used and how much is available to the next trophic level of the food web.

Organisms that use photosynthesis to harness energy are only able to convert about one percent of the total light energy that hits them into usable chemical energy. Of that energy that is harnessed by producers through photosynthesis, about 30% is used during metabolic processes and dissipated as heat, and about 70% becomes stored energy.

Ecological Pyramids

Not all plants or animals at one level are eaten by organisms at the next level. Some parts of plants or animals are not edible, for example, wood, peel of some fruits, some seeds, shells, and bones. In addition, much of the energy is lost as heat, energy is transferred to the next level. This relationship between producers and consumers can be demonstrated through **ecological pyramids.**

Ecological pyramids are models that show how energy flows through ecosystems and are graphic representations of trophic levels in an ecosystem. The producers make the base of the pyramid and subsequent tiers of the pyramid represent herbivore, carnivore and top carnivore levels.

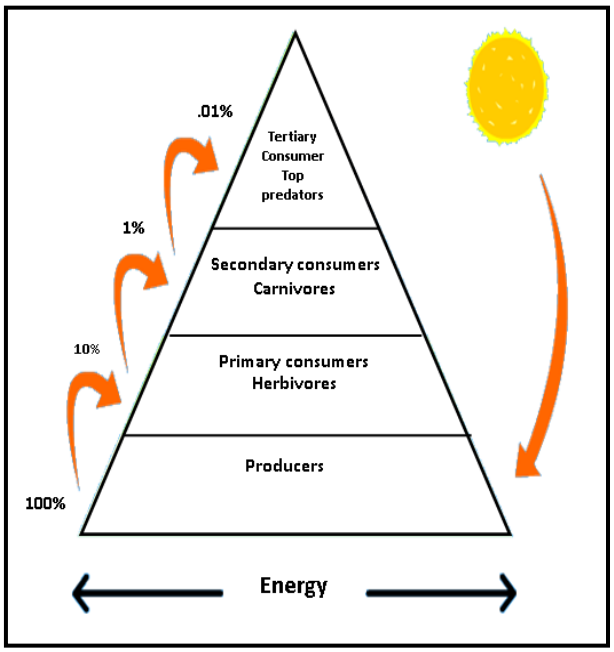
The base of the pyramid represents producers. Each step above the producer level represents a different consumer level. The number of trophic levels in the pyramid is determined by the number of organisms in the food chain or food web. Because the amount of energy coming into an ecosystem is limited and most of the energy in one trophic level is used by those organisms or converted to heat, ecosystems are limited in the number of trophic levels they can have.

They are pyramidal in shape and they are of three types. Pyramids can show the relative amounts of energy, biomass, or numbers of organisms at each trophic level in an ecosystem.

1. **Energy pyramid**

An energy pyramid represents the energy available for each trophic level in an ecosystem. It shows how the energy flows through a food chain, also how the energy is decreasing and becoming less available to the organisms. Each successive level in an ecosystem can support fewer numbers of organisms than the one below.

Since most of the energy available to a trophic level is used by those organisms or converted to heat, there is generally a 90% loss of available energy from one trophic level to the next. In general, only about 10% of the energy entering a trophic level is transferred to the trophic level above it, so the energy pyramid always has a distinct step-like pattern with less energy entering each trophic level up the food chain.



Energy pyramid

The source of energy in the food chain is the Sun.
If 100% of energy is available at the first trophic or at the base of the pyramid is reduced and only 10% moves to the next level, then there is only 1% of energy available at the highest trophic level. This loss goes on at every level until only 0.01% reaches the top consumers.

The total amount of energy available at each level decreases in an ecosystem.

For example, if there are 1000 units of energy available to the primary producer level, only 100 units will be available to the primary consumer level and only 10 units to the secondary consumer level. Because the amount of energy coming into an ecosystem is limited and most of the energy in one trophic level is used by those organisms or converted to heat, ecosystems are limited in the number of trophic levels they can have.

2. **Pyramid of numbers**

This represents the number of individual organisms available for energy at each trophic level in an ecosystem. It is used to examine how the population of certain species affects another. The total numbers of individual organisms tend to decline as one goes up trophic levels.

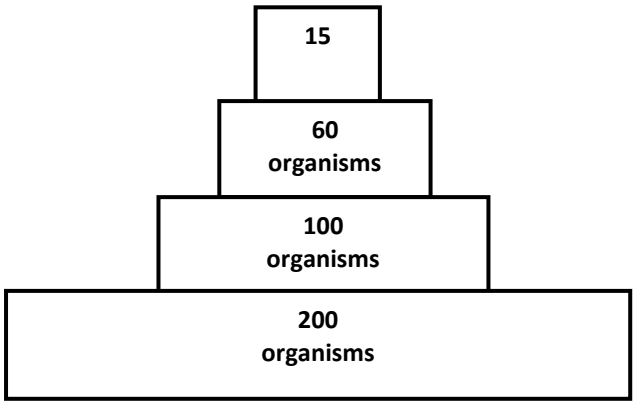
The numbers pyramid shows how the number of individuals per trophic level varies across trophic levels. If the number of individuals in a trophic level is related to the amount of energy entering that level then the number of individuals per level should also show a pyramidal shape. However, many factors can influence this relationship including the shape of the biomass pyramid and size of individuals.

If the **biomass pyramid** is not shaped like a pyramid th en it is unlikely that the **numbers pyramid** will either. For example, when insect herbivores feed on large trees, the difference in sizes between individuals in each level will cause there to be more individual herbivores than individual plants.

The loss of energy at each trophic level also explains why there are usually fewer organisms in each higher trophic level. The total number of plants in a particular area would generally be higher than the number of herbivores that the plants support and the number of herbivores would be higher than the number of higher order carnivores. For example, in a grassland the number of grasses is more than the number of herbivores that feed on them and the number of herbivores is more than the number of carnivores.

In some instances, the pyramid of number may be inverted, which are herbivores, are more than primary producers as you may observe that many caterpillars and insects feed on a single tree.

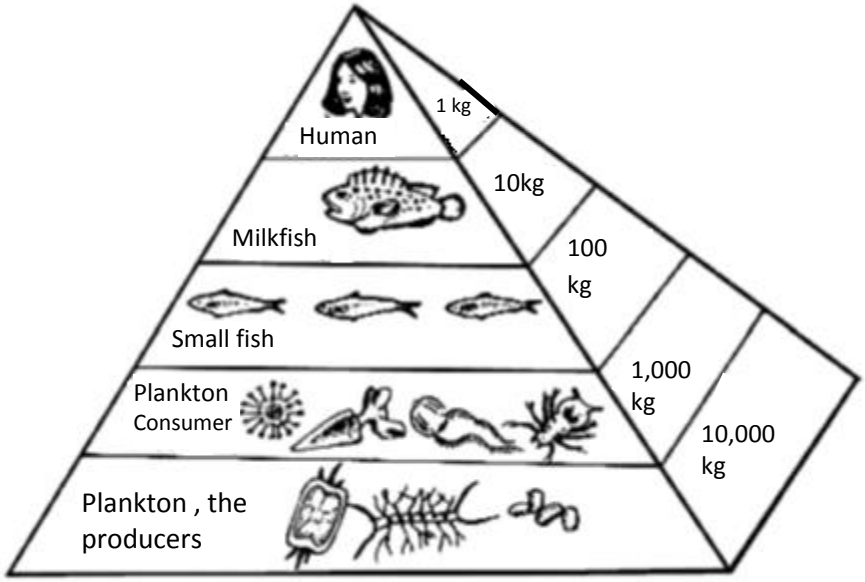
The autotrophic level is represented at the base of the pyramid. This represents the total number of producers available to support the energy needs of the ecosystem.



Pyramid of numbers in a grassland

3. **Pyramid of biomass**

The transfer of matter expressed as biomass and energy in food from one trophic level to another are not one hundred percent used. **Biomass** is the total mass of organisms in a food chain or a food web. Biomass is related to the abundance of organisms at each trophic level.



Pyramid of biomass

A **biomass pyramid** represents the total mass of living organic matter (biomass) at each trophic level in an ecosystem. The biomass pyramid shows how the biomass of living organisms varies across trophic levels. Since the number of organisms is reduced in each successive trophic level, the biomass at each trophic level is reduced as well.

Even though a biomass pyramid shows the total mass of organisms available at each level, it does not necessarily represent the amount of energy available at each level. For example, the skeleton and beak of a bird will contribute to the total biomass but may not be available for energy.

The shape of the biomass pyramid in any ecosystem depends on a number of factors. If the amount of biomass in a trophic level depends on the amount of energy entering that trophic level, then, all else being equal, the biomass pyramid should have the same shape as the energy pyramid. However, when biomass of primary producers is rapidly removed by herbivores. the biomass of primary consumers (herbivores) in an ecosystem at any time may be greater than the biomass of primary producers (example plants). Thus, the resulting biomass pyramid is not necessarily shaped like a pyramid.

The shape of the biomass pyramid is also influenced by the growth form of dominant plants in the ecosystem. For example, woody plants store biomass that has been accumulated for a number of years so there might be much more biomass in the

primary producer trophic level in ecosystems dominated by long lived woody plants (example, forests) than in ecosystems dominated by herbaceous plants (example, grasslands).

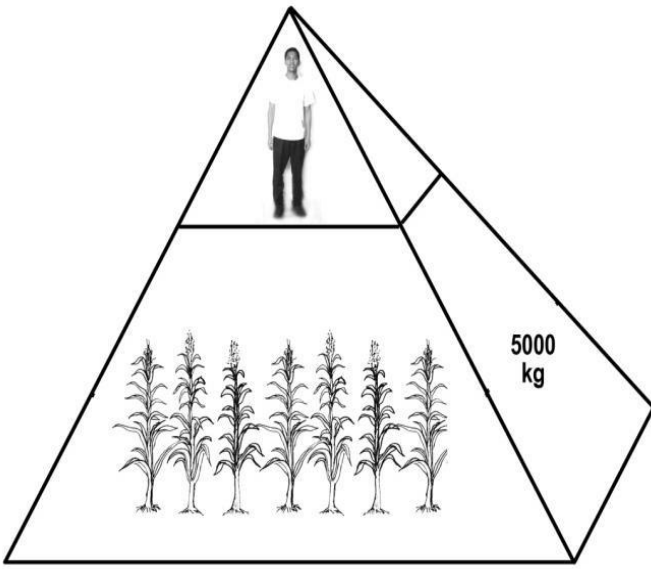
It is now time for you to complete Learning Activity 3. Remember, learning activities are not sent in for assessment. However, this learning activity will help you complete Practical Activity 1 (which you will send in for assessment)

Learning Activity 3

40 minutes

Meat eaters versus plant eaters

What can you infer from the biomass pyramids ?



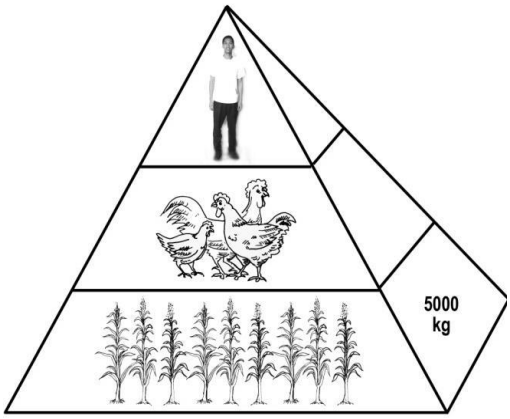
A. Study the following pyramid of biomass.

1. How much biomass of humans can 5 000 kg of corn support?

_____

_____

B. This time, study the following pyramid of biomass.



2. How much biomass of chicken can 5 000 kg of corn support

_____

_____

3. How much biomass of humans can the chickens support?

_____

_____

4. Which is more efficient in converting biomass of producers to biomass of consumers, a meat eater or a plant eater? Give your explanation.

_____

_____

_____

Thank you for completing your Learning Activity 3. Check your work. Answers are at the end of this module.

It is now time for you to complete Practical Activity 1 in your Assessment Book 1 before going on to the next topic.

Biomagnification is the process in which pollutants become more and more concentrated in living tissue. Biomagnification enables a pollutant that is found in small amounts in the environment to become highly concentrated in the tissues of large organisms**.**

Biomagnification occurs because the pollutant will become stored in the bodily tissue of every organism that consumes it.

A toxin will first be absorbed in small amounts by phytoplankton. Species at the bottom of the food chain (like zooplankton and aquatic insects) will eat large amounts of this phytoplankton.

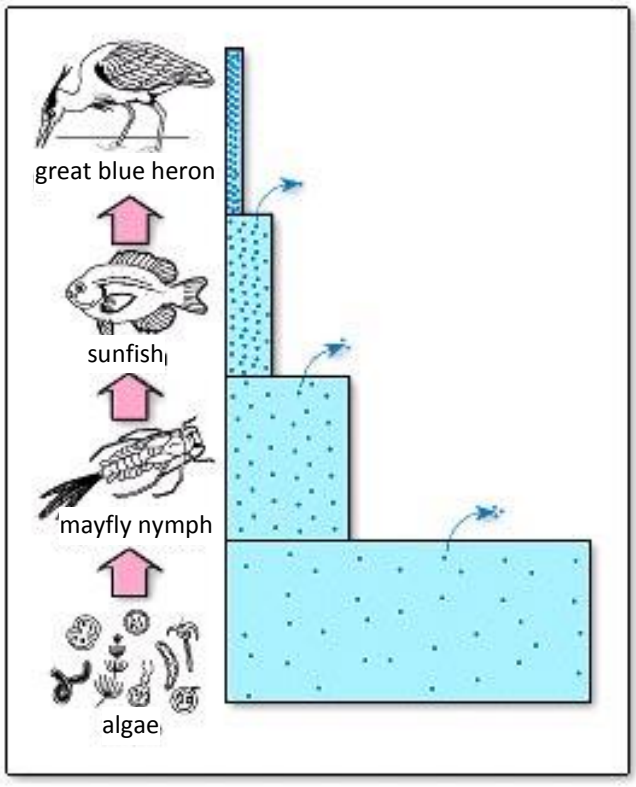
Small fish will eat large amounts of these zooplankton and macro invertebrates (insects), and these small fish will be eaten by larger fish. Macro invertebrates and zooplankton will eat many of these phytoplanktons.

Many of these insects, which have eaten many of this phytoplankton, will be eaten by small fish. All of the pollutants absorbed by the phytoplankton are trapped in the tissue of the insects and are now in the bodies of the fish.

All of the pollutants trapped in these fish will become trapped in the bodies of larger fish and other large predators (including mammals, birds, and humans).

Biomagnification increases with every step in the food chain. It is a process in which chemical substances become more concentrated at each higher trophic level.

Such chemical substances tend to be difficult to be removed from animals and plant tissues.



Biomagnification in an aquatic environment

The result is that when plants have the substance in them, they are eaten by herbivores. As each herbivore eats more of the plant, the substance accumulates in the herbivore.

When the herbivores are eaten by carnivores, the substance accumulates in the carnivore. As more herbivores are eaten, the amount of the chemical substance increases in the carnivore. This scenario repeats itself at higher trophic levels, so that the top consumer has very high levels of the substance in its tissues. Often, such high levels of chemical substances cause mutations, cancers and eventually death.

Nitrates and phosphates are nutrients that plants need to grow. In small amounts they are beneficial to many ecosystems. In excessive amounts, however, nutrients cause a type of pollution called **eutrophication.**

Eutrophication is the process in which the levels of water nutrients become too high, eventually causing dissolved oxygen levels in the water to become too low. It stimulates an explosive growth of toxic algal blooms like red tides, brown tides, that depletes the water of oxygen when the algae die and are eaten by bacteria.

Eutrophication is often devastating to animals and plants in estuaries as well as the economies of communities surrounding estuaries.

Estuarine waters may become hypoxic (oxygen poor) or anoxic (completely depleted of oxygen) from algal blooms. While hypoxia may cause animals in estuaries to become physically stressed, anoxic conditions can kill them.

Nutrient pollution often causes explosive algal growth, which depletes the water of oxygen when the algae die. Toxic and foul-smelling compounds may also be produced through this process.(Photo: Weeks Bay NERRS site)

Biogeochemical Cycles

Members of an ecological community depend on the exchange of resources in continual cycles. Cycles within an ecosystem intersect with larger regional and global cycles.

Earth's source of energy from the sun is infinite, as far as is known. This energy flows through the biosphere and constantly transfers from producers to consumers. We have already seen that while energy does not cycle through an ecosystem, chemicals do.

A cycle consists of a series of changes that lead back to a starting point or involve a continuous sequence of occurrences that are repeated.

Matter, such as carbon, oxygen, nitrogen, and phosphorus, is finite and, therefore, needs to cycle or the supply of matter will run out. The inorganic nutrients cycle through more than the organisms, however, they enter the atmosphere, oceans, and even rocks. Since these chemicals cycle through both the *bio*logical and *geo*logical world, we call the overall cycles, **biogeochemical cycles**.

There are two important components of a biogeochemical cycle.

1. **Reservoir pool** - atmosphere or rock, which stores large amounts of nutrients.
2. **Cycling pool or compartments of cycle** - they are relatively short storages of carbon in the form of plants and animals.

This cycling of materials includes the oxygen-carbon dioxide cycle, water cycle, and nitrogen cycle.

Water cycle, 97% ocean

The Water Cycle

You have already studied that earth is a watery planet of the solar system. About two thirds (2/3) of earth surface is covered with water. However, a very small fraction of this is available to animals and plants. Water is essential for life. No organism can survive without water.

Water circulates around the environment – the oceans, land, air and living organisms.

3% ice

Water is not evenly distributed throughout the surface of the earth. Almost 95 % of the total water on earth is chemically bound to rocks and does not cycle.

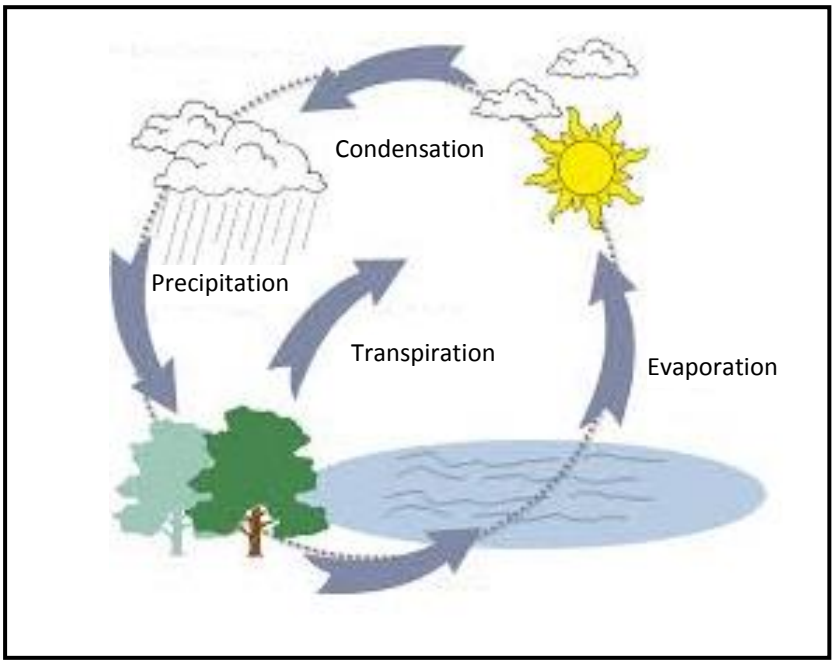
Out of the remaining 5%, nearly 97.3% is in the oceans and 2.1% exists as polar ice caps. Thus only 0.6% is present as fresh water in the form of atmospheric water vapours, ground and soil water.

Water received from the atmosphere on earth returns back to the atmosphere as water vapour resulting from direct evaporation and through evapotranspiration. The continuous movement of water in the biosphere is called **water cycle (hydrological cycle).** The cycling process involves evaporation, transpiration, condensation, and precipitation.

The driving forces for the water cycle are:

1) solar radiation.
2) gravity.

In the water cycle, energy is supplied by the sun, which drives evaporation whether it be from ocean surfaces or from treetops. The sun also provides the energy which drives the weather systems which move the water vapour (clouds) from one place to another (otherwise, it would only rain over the oceans.



The Water Cycle

Evaporation and **precipitation** are two main processes involved in the water cycle. These two processes alternate with each other.

Evaporation is the reverse process in which liquid water becomes gaseous. **Precipitation** occurs when water condenses from a gaseous state in the atmosphere and falls to earth.

When solar energy warms the Earth's surface, water evaporates from the oceans, rivers, lakes and land. The escape of water through leaf pores (transpiration) adds water vapor to the atmosphere. Upon cooling at higher altitude, water vapor condenses and forms clouds. Once water condenses, gravity takes over and the water is pulled back to the ground.

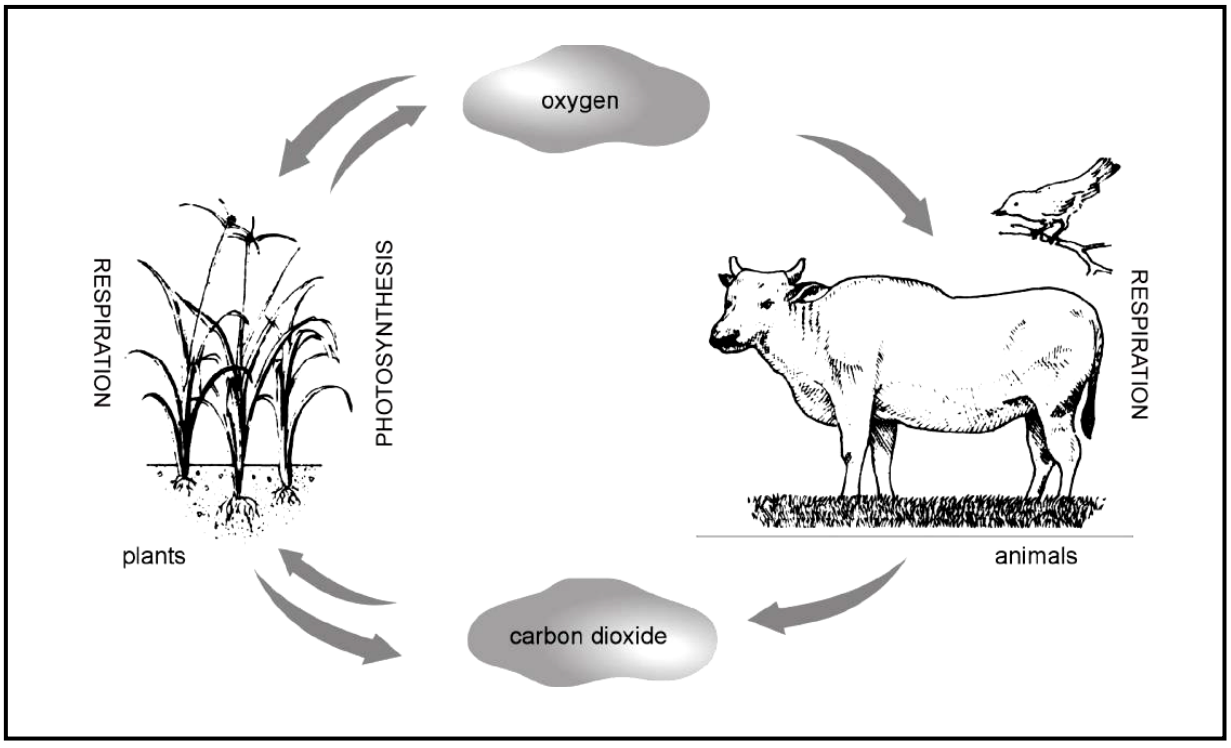
Gravity continues to operate, either pulling the water underground (groundwater) or across the surface (runoff). In either event, gravity continues to pull water lower and lower until it reaches the oceans (in most cases; the Great Salt Lake, Dead Sea, Caspian Sea, and other such depressions may also serve as the lowest basin into which water can be drawn). Frozen water may be trapped in cooler regions of the Earth.

Eventually, precipitation occurs in the form of rain or snow. On land, plant roots absorb water. In tropical rainforests, over 90 percent of the moisture is cycled through transpiration in plants. Some water seeps downwards and replenishes the ground water. The excess eventually overflows into the oceans and the water cycle continues.

The Oxygen – Carbon Dioxide Cycle

Once you understand the water cycle, the carbon cycle is relatively simple. Organisms use and produce gases in photosynthesis and respiration. These gases flow through organisms and the environment in a cyclic process called the **oxygen-carbon dioxide cycle.** The oxygen-carbon dioxide cycle shows the interdependence among organisms for these important gases.

When plants photosynthesize, they use carbon dioxide and produce oxygen. Photosynthesis takes energy from the sun and stores it in the form of carbohydrates; respiration releases that energy. Both plants and animals carry on respiration, but only plants (and other producers) can carry on photosynthesis. The chief reservoirs for carbon dioxide are in the oceans and in rocks.



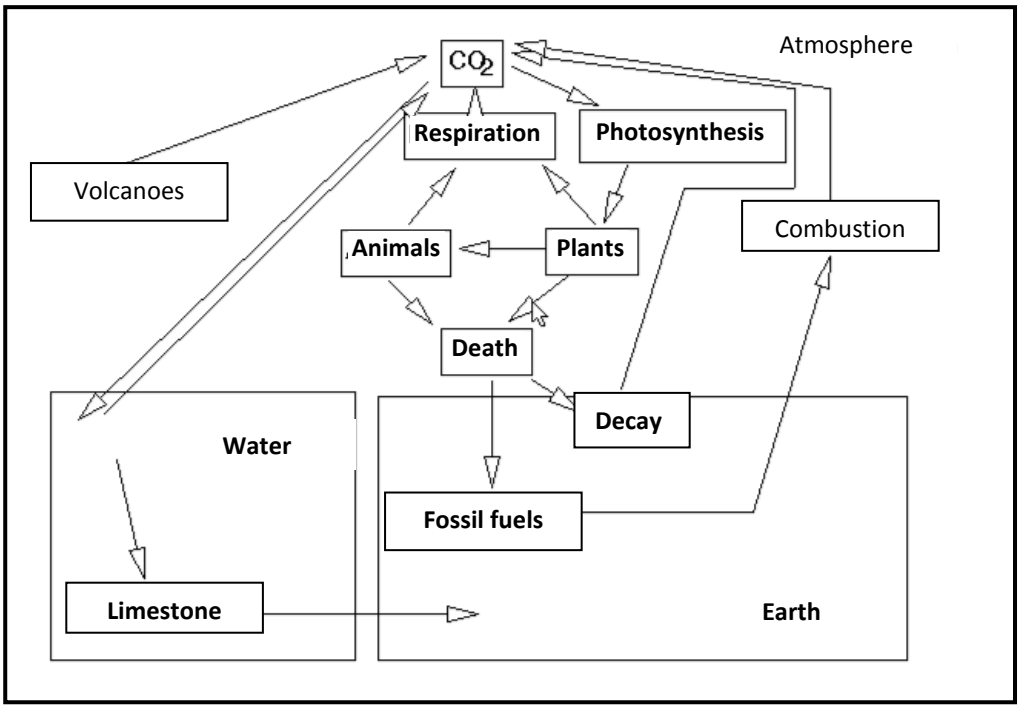
Oxygen and carbon dioxide are continuously availed of by plants and animals through the oxygen-carbon dioxide cycle.

Oxygen produced by plants in photosynthesis is used by animals when they respire; animals in turn produce carbon dioxide. Like animals, plants also carry out the process of respiration. During respiration, plants use oxygen and produce carbon dioxide.

Animals take in oxygen from the atmosphere and give off carbon dioxide during respiration. This occurs day and night. Plants, however, give off oxygen and take in carbon dioxide when they photosynthesize during the day. At night, when plants are in darkness and cannot photosynthesise, they “breathe” just like animals. They take in oxygen and give off carbon dioxide.

Notice that plants and animals depend on each other for these important gases. Plants produce oxygen needed by animals. In turn, animals produce carbon. Carbon dioxide dissolves readily in water. Once there, it may precipitate (fall out of solution) as a solid rock known as calcium carbonate (limestone). Corals and algae encourage this reaction and build up limestone reefs in the process.

On land and in water, plants take up carbon dioxide and convert it into carbohydrates through photosynthesis. This carbon in the plants now has 3 possible fates. It can be liberated to the atmosphere by the plant through respiration; it can be eaten by an animal, or it can be present in the plant when the plant dies. Carbon from plants or animals that is released to the atmosphere through respiration will either be taken up by a plant in photosynthesis or dissolved in the oceans.



Oxygen- Carbon cycle

When an animal or a plant dies, it can either be respired by decomposers (or released to the atmosphere), or it can be buried intact and ultimately form coal, oil, or natural gas (fossil fuels).

Fossil fuels can be mined and burned, releasing carbon dioxide into the atmosphere. Otherwise, the carbon in limestone or other sediments can only be released to the atmosphere when they are subducted and brought to volcanoes, or when they are pushed to the surface and slowly weathered away.

Humans have a great impact on the carbon cycle because when we burn fossil fuels we release excess carbon dioxide into the atmosphere. This means that more carbon dioxide goes into the oceans, and more is present in the atmosphere. The latter condition causes global warming, because the carbon dioxide in the atmosphere allows more energy to reach the Earth from the sun than it allows escaping from the Earth into space.

The Nitrogen Cycle

The nitrogen cycle is one of the most difficult of the cycles to learn, simply because there are so many important forms of nitrogen, and because organisms are responsible for each of the inter conversions.

Nitrogen is an essential component of protein and required by all living organisms including human beings. Organisms use nitrogen to build proteins and nucleic acids. Remember that nitrogen is critically important in forming the amino portions of the amino acids which in turn form the proteins of your body. Proteins make up skin and muscle, among other important structural portions of your body, and all enzymes are proteins. Since enzymes carry out almost all of the chemical reactions in your body, it is easy to see how important nitrogen is.

About 79 percent of the gases in the atmosphere is made up of nitrogen gas but it cannot be used directly by the majority of living organisms. Broadly like carbon dioxide, nitrogen also cycles from gaseous phase to solid phase then back to gaseous phase through the activity of a wide variety of organisms. Cycling of nitrogen is vitally important for all living organisms.

Five main processes which are essential for the nitrogen cycle are given below.

1. **Nitrogen fixation**
   Some bacteria convert nitrogen to ammonia a form in which it can be used by plants. This process is called nitrogen fixation. These bacteria are known as nitrogen-fixing bacteria. They live in soil and are abundant in the nodules of legumes such as mungo beans.

   Atmospheric nitrogen can be fixed by the following three methods:

   (i) **Atmospheric fixation**
   Lightening, combustion and volcanic activity help in the fixation of nitrogen. First, lightning provides enough energy to "burn" the nitrogen and fix it in the form of nitrate, which is nitrogen with three oxygen attached. This process is duplicated in fertilizer factories to produce nitrogen fertilisers.

   (ii) **Industrial fixation**
   The experiments of Stanley Miller, who used electrical discharges to show how nitrogen in the Earth's early atmosphere might have combined to form amino acids. At high temperature (400°C) and high pressure (200 atmosphere.), molecular nitrogen is broken into atomic nitrogen which then combines with hydrogen to form ammonia.

(iii) **Bacterial fixation**

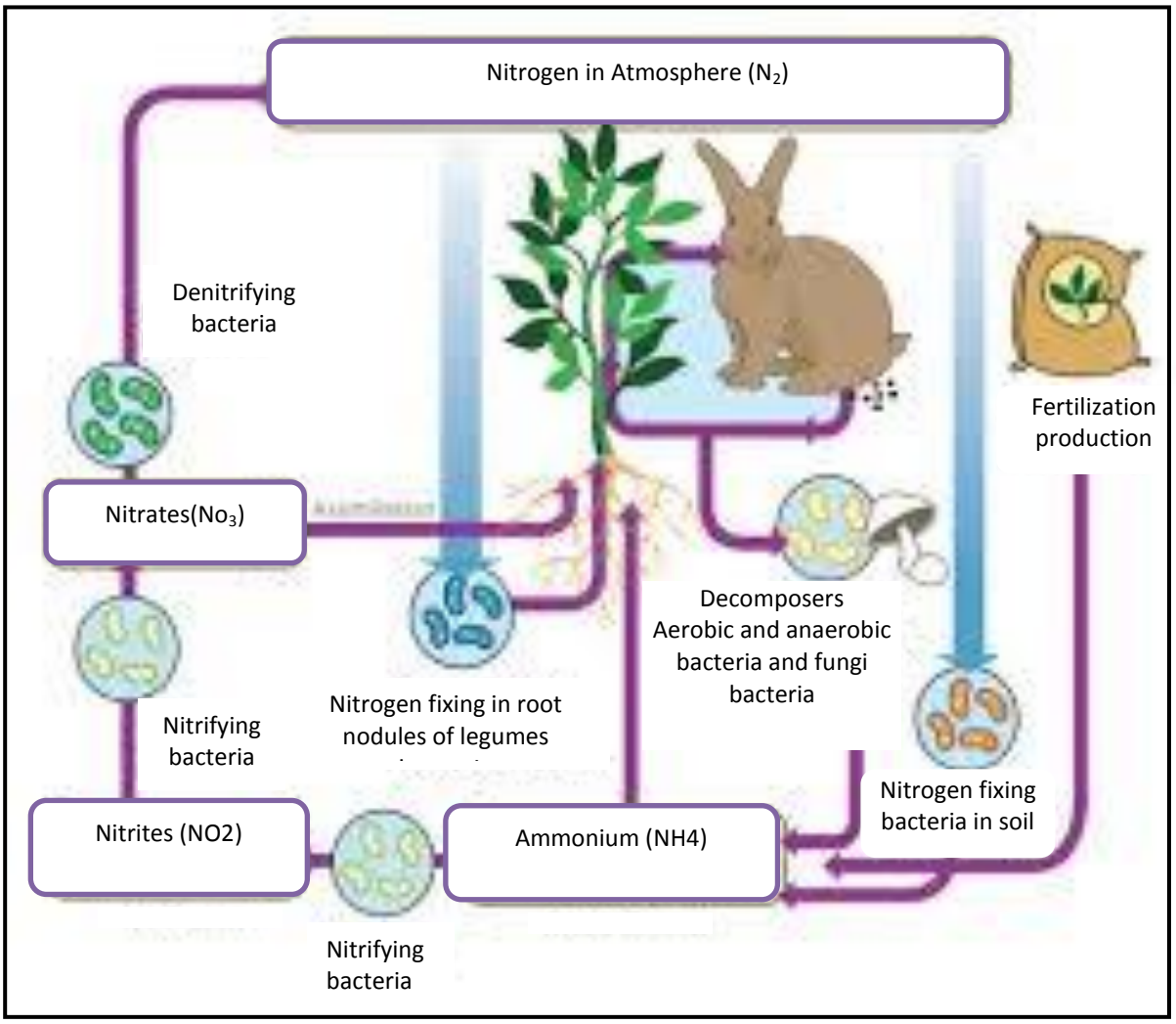
The other form of nitrogen fixation is by nitrogen fixing bacteria, which use special enzymes instead of the extreme amount of energy found in lightning to fix nitrogen.

These nitrogen-fixing bacteria come in three forms:

(a) **symbiotic bacteria** for example Rhizobium in the root nodules of leguminous plants, mutualistic associations with the roots of bean plants and other legumes (rhizobial bacteria).

(b) **free - living in the soil**
For example Nostoc, Azobacter can combine atmospheric or dissolved nitrogen with hydrogen to form ammonia.

(c) **photosynthetic cyanobacteria** (blue-green algae) which are found most commonly in water. All of these fix nitrogen, either in the form of nitrate or in the form of ammonia.



Nitrogen cycle

2. **Nitrification**

It is a process by which ammonia is converted into nitrates or nitrites by *Nitrosomonas* and *Nitrococcus* bacteria respectively. Another soil bacteria, *Nitrobacter* can covert nitrate into nitrite. The activities of these nitrifying bacteria are important because nitrogen is mostly taken up by plants as nitrates. Plants also use ammonium salts but not nitrites that are toxic to them. This conversion of ammonium salts to nitrates is called nitrification.

When plants or animals die (or release waste) the nitrogen is returned to the soil. The usual form of nitrogen returned to the soil in animal wastes or in the output of the decomposers, is ammonia. Ammonia is rather toxic, but, fortunately there are nitrite bacteria in the soil and water which take up ammonia and convert it to nitrite, which is nitrogen with two oxygen, which can be taken up by plants to continue the cycle.

3. **Assimilation**

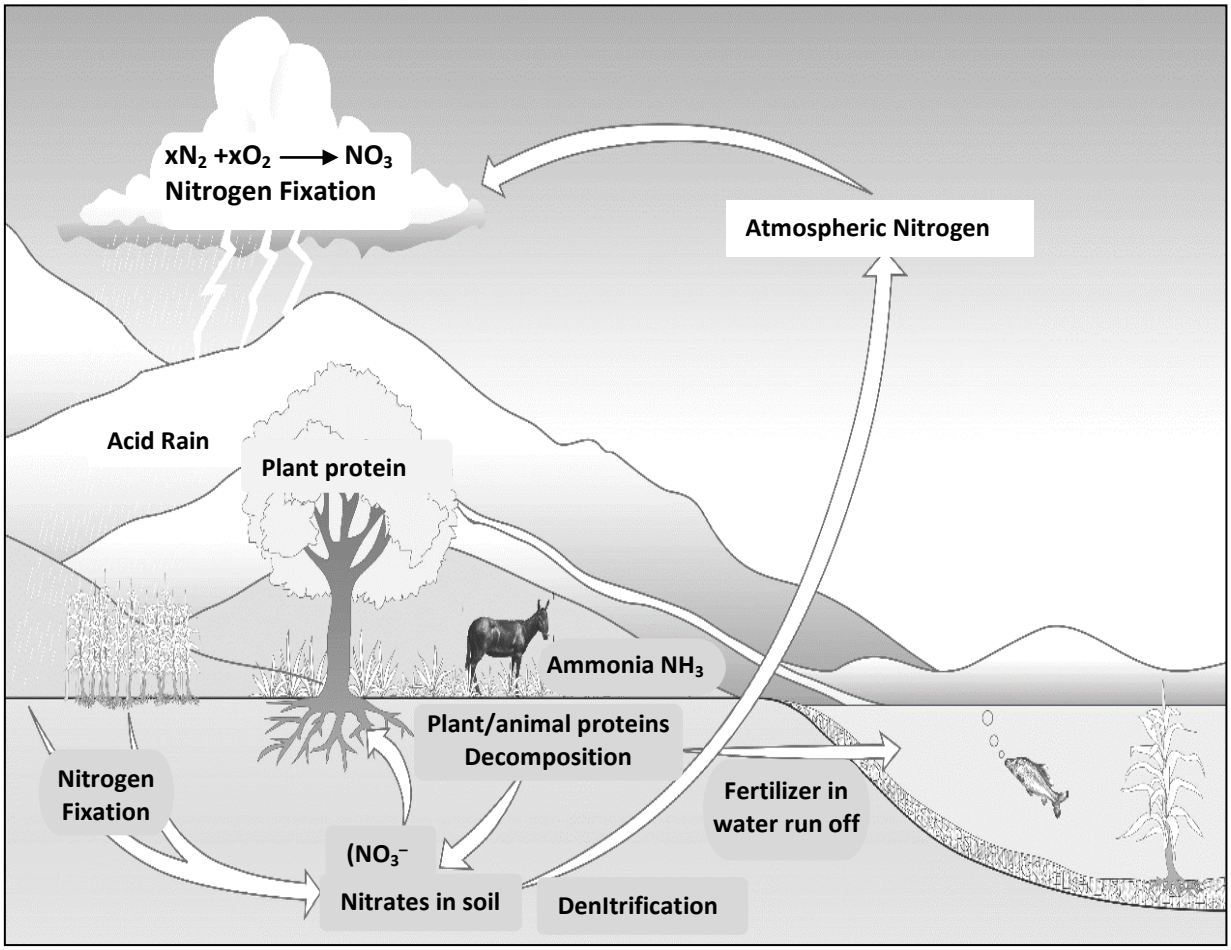
In this process nitrogen fixed by plants is converted into organic molecules such as proteins, deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). These molecules make the plant and animal tissue. Plants absorb nitrogen in the form of nitrates and ammonium salts, and use it to manufacture the proteins they need. Animals obtain the nitrogen they need by eating either plants, or other animals that have eaten plants.

4. **Ammonification**

Living organisms produce nitrogenous waste products such as urea and uric acid. These waste products as well as dead remains of organisms are converted back into inorganic ammonia by the bacteria. This process is called **ammonification**. **Ammonifying bacteria** help in this process. When plants and animals die or excrete they return nitrogen back to the soil. We now have a cycle set up in the soil (or water), but what returns nitrogen to the air? It turns out that there are denitrifying bacteria which take the nitrate and combine the nitrogen back into nitrogen gas.

5. **Denitrification**

Denitrifying bacteria live deep in soil near the water table as they like to live in oxygen free medium. Denitrification is reverse of nitrogen fixation or conversion of nitrates back into gaseous nitrogen. Certain bacteria and fungi reduce nitrates in the soil to gaseous nitrogen thus lessening the amount available to plants. The denitrifying bacteria are especially active in soils such as badly drained soils which are short of oxygen.



Nitrogen cycle

The nitrogen cycle has some important practical considerations, as anyone who has ever set up a saltwater fish tank has found out. It takes several weeks to set up such a tank, because you must have sufficient numbers of nitrite and nitrate bacteria present to detoxify the ammonia produced by the fish and decomposers in the tank.

The ammonia levels in the tank will build up and kill the fish. This is usually not a problem in freshwater tanks for two reasons. First, the pH in a freshwater tank is at a different level than in a saltwater tank. At the pH of a freshwater tank, ammonia is not as toxic. Second, there are more multicellular plant forms that can grow in fresh water, and these plants remove the ammonia from the water very efficiently. It is hard to get enough plants growing in a saltwater tank to detoxify the water in the same way.

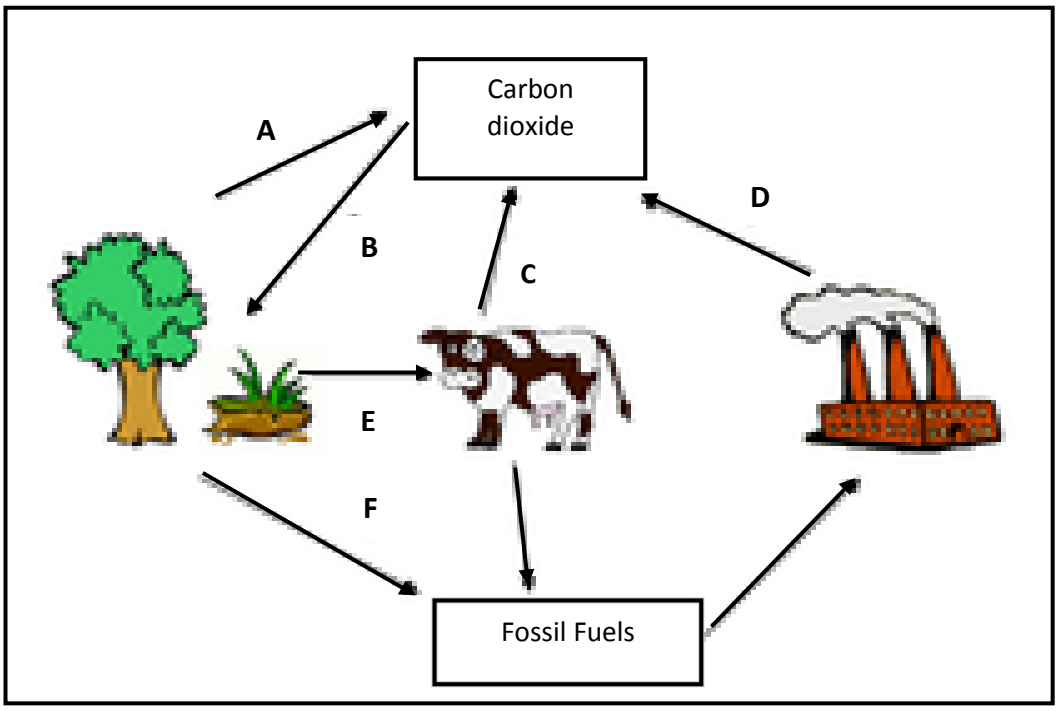
It is now time for you to complete Learning Activity 4 on the next page. Remember, learning activities are not sent in for assessment. However, this learning activity will help you complete Assignment 1 (which you will send in for assessment)

Learning Activity 4

40 minutes

The Carbon Cycle

Refer to the diagram below to answer Questions 1 to 5.



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1. Label the arrows with the name of the process each represents. Use the words from the text box below (there may be duplications).

Combustion	Death	Photosynthesis	Respiration	Feeding

A. _____ B. _____ C. _____

D. _____ E. _____ F. _____

2. Which two processes require oxygen to release energy?

A. _____ B. _____

3. How many of the processes remove carbon dioxide from the atmosphere? _____

4. What form does the carbon take inside a tree? _____

5. How does decomposition release carbon dioxide into the atmosphere?

_____

Thank you for completing your Learning Activity 4. Check your work. Answers are at the end of this module.

Ecosystem Succession

What is an ecosystem succession?

Most of the time, when we talk about an ecosystem or habitat, we assume that it is stable and not changing. This is not always the case in nature. All life forms from individual organisms to species to ecosystems changes over time.

Some habitats may relatively remain unchanged for hundreds or even thousands of years. There are others that undergo dramatic changes every few years. Over ecological time, the area may experience several transitions.

Individuals develop and learn, species adapt and evolve, and organisms in ecosystems co-evolve. For example, hummingbirds and honeysuckle flowers have developed in ways that benefit each other; the humming bird's colour vision and slender bill coincide with the colours and shapes of the flowers.

Within any community some species may become less abundant over some time interval, or they may even vanish from the ecosystem altogether. Similarly, over some time interval, other species within the community may become more abundant, or new species may even invade into the community from adjacent ecosystems. This observed change over time in what is living in a particular ecosystem is **ecosystem succession**.

Ecosystem succession is also called **ecological succession and is the process through which a natural community of plants and animals changes after a disturbance.** It is generally understood that ecological succession is a progressive movement towards a more stable community (also called a "climax community").

Why does ecological succession occur?

The ‘engine’ of succession or the cause of ecosystem change is the impact of established species has, upon their own environments. This kind of succession is the manner through which natural communities respond to disturbances and changes.

Every species has a set of environmental conditions under which it will grow and reproduce most optimally. In a given ecosystem, and under that ecosystem's set of environmental conditions, those species that can grow the most efficiently and produce the most viable offspring will become the most abundant organisms. As long as the ecosystem's set of environmental conditions remains constant, those species that optimally adapted to those conditions will flourish.

The original environment may have been optimal for the first species of plant or animal, but the newly altered environment is often optimal for some other species of plant or animal. Under the changed conditions of the environment, the previously dominant species may fail and another species may become ascendant. Ecological succession is the natural process in which some species are replaced by other species in a predictable pattern**.**

Ecological succession may also occur when the conditions of an environment suddenly and drastically change. The causes of these changes can be natural occurrences, which include fire, floods, volcanic eruptions, tsunamis, wind storms, landslides, avalanches and glacial retreat.

These are some examples of elemental ecological disturbances that greatly alter the conditions of an environment. Sometimes the changes are caused by human activities, such as logging, dam building, mining, urbanisation, farming and agricultural use. In either case, if the change is severe enough to strip of away the existing vegetation or expose a new landscape, species will colonise the disturbed area and then likely be replaced by other species.

There are two basic types of ecological succession, which are categorised based on how many nutrients or lack thereof are already present in the soil after the disturbance.

Types of Succession

1. **Primary succession** is when a community first forms in a newly created or exposed area such as a sand dune or bare rock surface, lava flow, or a new lake created by flooding. In a sense, this is as if the community forms from a "clean slate" ecologically speaking. Primary succession begins when organisms such as simple plants, fungi, lichens, or other microscopic organisms begin to inhabit bare rock or other lifeless areas. Succession can be the introduction and growth of living organisms to areas where nothing has grown before, like on bare rock or succession that begins in an area where the soil has not yet formed.

2. **Secondary succession** is when a community was disturbed by human or elemental forces. It begins after an event clears the community but leaves the soil intact.

   This form of succession tends to be much more rapid as some of the vital elements such as soil, nutrients and seeds are already present at the location at least to some extent.

   An example of this kind of succession is a forest recovering from a major forest fire or logging event, formation of a new island by a volcanic eruption or the retreat of a glacier.

Clear cutting: When forests are clear-cut, secondary succession begins on the deforested plots. To speed the process, and to ensure that the resulting forest will be the same age and easy to harvest, timber companies usually replant the forest. This, however, results in a forest of trees which are often genetically very similar, and of course, of the same age. This creates a patchwork landscape as you can see in this picture. Because these forests do not retain any of the old trees which provide food and nest sites for many animals, they are not very diverse in terms of wildlife either. Wildlife depends on a diversity of trees which themselves vary in age from saplings to mature and even dead trees.

Succession in your neighbourhood

Primary succession begins when organisms such as simple plants, fungi, lichens, or other microscopic organisms begin to inhabit bare rock or other lifeless areas. As you learned in lower science, lichens cause chemical weathering by secreting an acid into the rock that causes the rock to soften.

The surface of the rock may then slowly break down and create a shallow layer of sediment. Seeds brought by birds, wind, or water may settle in this sediment, grow for a short period of time, die, and subsequently add nutrients to the soil.

Insects and other small animals may come to the area to feed on small plants and other insects that live there. In turn these animals will contribute to the collection of nutrients in the sediment which has begun to turn into a richer, more fertile soil that can support larger plants.

Primary succession on Rangitoto Island

As larger plants grow, their roots help to break down the rock further through physical weathering. The plants attract larger animals that search for shelter and food. These

animals may bring different foods to the area unknowingly, in the form of seeds stuck on their furs and bodies or undigested food in their wastes. Other animals then become attracted to the area because of the new wealth of food, both plant and animal.

Change will continue in this area until a **climax community** is reached. This occurs when the type of organisms living in the area become stable, and the community as a whole is self - sustaining. Self-sustaining means that everything that the population needs to survive is provided by that community.

Succession in PNG

Papua New Guinea, where volcanic activity and earthquakes are fairly frequent and there has been a long tradition of shifting cultivation, there are large areas of regenerating forest and therefore a fairly elaborate mosaic of pioneer and climax forest.

Tropical rainforests go through several stages during regeneration. A small gap, such as that caused by the death of a small tree, or the loss of a limb, will not alter much in the forest.

Limbs from other trees will fill in a gap and their shade will prevent the growth of most seedlings on the forest floor, except for those which do not require much light. A somewhat larger gap changes the physical state of that area of the forest. There will be more light, heat, and wind on the forest floor where a gap forms.

Tropical rainforest in Papua New Guinea

The forest floor of the gap will become hotter and drier than previously, although more rain will reach the ground (but it will be dried quickly by the sun). The temperature here can be as much as 10°C higher than under the canopy.

At this early successional stage, the extent of seedling sprouting and survival is determined mainly by factors in the environment – competition, nutrient availability, temperature, degree of shade. Then those seedlings which survive begin to influence their own environment as they grow by producing shade, using soil organic matter, and producing new types of habitats. At the same time, epiphytes and climbing plants begin to colonise the growing young trees.

The early pioneer trees are often low and short-lived, and may be replaced by longer-lived, taller pioneer species which form a higher canopy forest. Meanwhile, the seedlings of climax species remain undeveloped in the shade of pioneer trees, as they do not do well under gap conditions of high temperatures and high light intensities.

As large pioneer trees die, conditions are conducive for the small trees of the climax species to grow rapidly and take their place. (While climax species' seedlings are shade-requiring, older specimens actively seek light.)

Once established, a climax forest can reproduce itself endlessly, since it provides shade for its seedlings, and the large trees have attained the canopy. This series of events is what Whitmore (1998) calls a "shifting mosaic steady state." (Although pioneer and climax species are defined here as having quite different characteristics, in truth all of these species lie on a continuum and it is not always easy to define these terms.)

It is important to remember that succession is a process that is happening all around us all the time. It is the means through which the natural world recovers from disturbance, and it is a process vital to the survival of plant and animal communities around the world.

It is now time for you to complete Assignment 1 in your Assessment Book 1 before going on to the next topic.

12.1.3 Human Impacts on the Environment

The information regarding our human impact is vast and impossible to cover in one module but we will attempt to cover a basic overview.

What is the human impact on the environment?
Every living organism has an impact on its environment. Human populations have a greater impact on ecosystems than populations of most other living things do. Therefore, human impact on the environment is inevitable. By simply existing, all species including ourselves will imprint their mark on the world around them. What differentiates us from other species is our ability to greatly overburden our environment with very few limits put upon us.

Humans are one animal species involved in these processes that have a great impact on the flow of energy and cycling of matter. Human influence on balance in the biosphere can be positive (example a helpful technology) or negative (example, pollution) and intentional or unintentional.

Environmental Issues/Problems – Human Activities that affect the environment

How do human activities affect the ecosystem?
Some of us live in very large numbers in fairly small areas. While others spread out to fill large area. Either way, our need for resources is great, because there are so many of us. We also use resources that other organisms do not use. For instance, we dig deep into the ground for petroleum to make fuels, plastics, and other products. Our activities can change ecosystems so much that their condition is often threatened.

In some cases, ecosystem balance is so disrupted that living things that once thrived in a certain place can no longer get the resources they need to survive there.

What is the importance of balancing energy flow and the cycles of matter in maintaining equilibrium with the biosphere? What happens when humanity intentionally or unintentionally affects this balance?

Humans are the top consumers in many food pyramids. To increase food production, they use methods that have an effect on food chains and food webs.

Some of the **farming practices** are described as follows:

1. **Monoculture**

   What is monoculture? From the words:

mono means single + **culture,** tilling of land

   Put them together, and it is clear that **monoculture** is the tilling of the land for a single crop. This is the cultivation of a single crop in large areas. Vast tracts of land are converted to rice farms, sugar farms, and coconut farms. It is important to recognise that there are many good reasons to grow crops in monoculture.

   Monoculture is a practice that has allowed many technological advances in crop production. Having only one crop in the field increases our ability to mechanise planting, weeding, and harvest.

   The mechanization of agriculture is the reason a majority of the population in developed countries does not still work on a farm. Without mechanisation, growing your own food is often a necessity, not a hobby.

   Major crops that are grown as a monoculture are grains (corn, wheat or rice), forage (alfalfa or clover), or fiber (cotton).

   These crops are called commodity crops because, they are used in a number of goods and products.

   How many times do you read soy, corn, or wheat when walking through a grocery store?

One plant in a pot. A monoculture?

To ensure the optimal yields of these crops, companies manufacture special strains of these crops and special fertilisers and pesticides.

Due to the technological advances from perfecting monocultures, crops are able to grow in scenarios where naturally they would have struggled.

What are the problems associated with monoculture production?
What is the big problem with monocultures? Let us explore why we all should be concerned about this practice.

Well, to start, when one crop is planted repeatedly on the same land, certain nutrients become depleted from the soil due to the crop's specific nutrient demand.

Taro monoculture in Papua New Guinea

Instead of rotating different crops to naturally restore the nutrients and vitamins that are found in the soil, monoculture farming causes the same nutrients to diminish from the ground.

In order to continue planting a single crop on the same land, these nutrients must be replaced some way which create the need to apply various chemical fertilisers.

Nitrogen is a key nutrient in crop growth. Plants, like soy, are able to "fix" nitrogen from the air back into the soil, where a crop like corn cannot. If you do not rotate between nitrogen fixing plants and non-nitrogen fixing plants, the soil will be depleted of this vital nutrient.

In addition, by limiting the cultivation of different kinds of plants, people also deprive many animals of their food and home. These animals, some of which feed on insect pests, move to other places. Only the insect pests that eat the monocrop remain in the area. If uncontrolled, these pests can totally wipe out the monocrop in a short time. If there were a variety of crops in one field, bugs and weeds might not be so inclined to go near the crops they did not like.

Some soil microorganisms depend on specific plants for food. Eliminating these plants is harmful to the microorganisms. Since microorganisms are responsible for returning plant nutrients to the soil, the cycling of nutrients for reuse of the plants is disturbed.

Risk to humans and animals

Soil that is nutrient deficient can be dry and susceptible to erosion. In turn, runoff pollution is very prevalent in waterways near monoculture fields.

Human are at risk of the negative impacts of monocultures as well! People living near pesticide laden fields could be drinking nitrate polluted water from their wells. In the United States, it is estimated that more than 25 percent of the drinking water wells contain nitrate levels above the 45 parts per million safety standard. Children in these areas have been shown to develop **methemoglobinemia** and adults have an increased chance of developing gastric, bladder and oesophageal cancers.

2. **Herbicides and insecticides**

Farmers spray their crops with insecticides to kill insect pests, and with herbicides to kill weeds. Remember all the herbicides and pesticides we need to protect these monocultures? However, the chemicals also destroy other organisms, including beneficial insects and soil organisms which help in decay.

Insecticides move up the food pyramid and accumulate in the body of organisms. The smallest concentration of the chemical is at the base of the pyramid occupied by producers. The amount increases towards the top. The greatest concentration is found in the top consumers such as birds, mammals, and humans.

Many insect pests become resistant to chemicals. This may lead to the use of increased amounts of pesticide.

3. **Chemical fertilisers**

Monocrops usually require large amounts of chemical fertilisers. Continuous and uncontrolled use of chemical fertilisers may increases soil acidity, thus destroying soil structure. Findings show that more fertilisers are needed for the same amount of yield after years of monoculture.

Fertilisers may run off to rivers, ponds, and lakes. Well they go wherever the run-off water goes Accumulation of fertilisers may cause the death of these bodies of water. Fertilisers in the water will cause increased growth of algae and other water plants. They cover the water's surface and block the passage of oxygen. Thus, less oxygen is dissolved in water.

Furthermore, when algae and aquatic plants die, decay microorganisms use oxygen. Dissolved oxygen becomes insufficient, causing fish and other aquatic animals to die.

Deforestation to make way for new palm oil in Papua New Guinea

Deforestation

Humans have always cut down trees throughout history. However, they now have the resources of multimillion-dollar equipment that drastically increases the rate of tree removal.

The world's rainforests are being destroyed at a rate of 78 million acres per year, resulting in vegetation degradation, nutrient imbalance, flooding and animal displacement.

Trees also act as a natural air filter in the carbon cycle by taking in carbon dioxide and releasing oxygen, so deforestation contributes to global warming. Some estimates indicate that canopy forest species will be reduced by 35 percent by 2040 if deforestation continues at the same rate.

Causes of deforestation

1. **Agricultural activities**

   Due to overgrowing demand for food products, huge amount of tress are fell down to grow crops and for cattle grazing.

   About 80% of PNG population relies on agriculture as a means of living and agriculture accounted for 30.4% of GDP. Cash Crops (Crops grown commercially) ranked by value coffee, oil, cocoa, copra, tea, rubber, and sugar.

   Plantation agriculture causes deforestation because large areas of land are cleared to make place for the plantations. Some of the inhabitants of PNG practise subsistence agriculture, however, plantation agriculture is a bigger threat as large companies have the resources necessary to clear a large amount of land.

2. **Logging**

   Apart from this, wood based industries like paper, match-sticks, and furniture also need a substantial amount of wood supply. Wood is used as fuel both directly and indirectly, therefore trees are chopped for supplies. Firewood and charcoal are examples of wood being used as fuel. Some of these industries thrive on illegal wood cutting and felling of trees.

   The demand for unprocessed logs from Asian markets is the greatest cause of forest loss in Papua New Guinea. PNG is the world's fifth largest producer of tropical logs. Most of the world's tropical logs are processed domestically by the producing countries however; this is not the case with Papua New Guinea.

3. **Urbanization**

   In order to gain access to these forests, the construction of roads are undertaken; here again trees are chopped to create roads. Overpopulation too directly affects forest covers, as with the expansion of cities more land is needed to establish housing and settlements. Therefore forest land is reclaimed.

4. **Desertification of land**

Some of the other factors that lead to deforestation is also part natural and part **anthropogenic** like desertification of land. It occurs due to land abuse making it unfit for growth of trees. Many industries in petrochemicals release their wastes into rivers which results in soil erosion and make it unfit to grow plants and trees.

5. **Mining**

Oil and coal mining require large amount of forest land. Apart from this, roads and highways have to be built to make way for trucks and other equipment. The waste that comes out from mining pollutes the environment and affects nearby species. Extraction of mineral ores in PNG such as nickel, copper, gold and natural gas is a major part of the economy, contributing to about ¼ of the Gross Domestic Product in 2001. The natural gas industry is growing as there is an estimated 22.5 trillion cubic feet of natural gas reserves in the country and which Exxon Mobil hopes to make use of by building a pipeline to Queensland, Australia.

The main reason for deforestation is that many of the mining companies are not concerned about their environmental impact, with the exception of BHP Billiton, which lists Safety and The Environment as one of its corporate values. Mines affect the forests because in densely vegetated areas, the mining companies have to cut down trees to be able to extract ore.

Note:

1. Exxon Mobil is an American Multinational oil and gas corporation. With 37 oil refineries in 21 countries constituting a combined daily refining capacity of 6.3 million barrels, Exxon Mobil is the largest refiner in the world.
2. BHP Billiton is the largest mining company by revenue, with headquarters in Melbourne, Australia.

6. **Forest Fire**

Another example would be forest blazes. Hundreds of trees are lost each year due to forest fires in various portions of the world. This happens due to extreme warm summers and milder winters. Fires, whether causes by man or nature results in huge loss of forest cover.

Effects of deforestation

1. **Climate imbalance**

Deforestation also affects the climate in more than one way. Trees release water vapour in the air, which is compromised on with the lack of trees. They also provide the required shade that keeps the soil moist. This leads to an imbalance in the atmospheric temperature further making conditions for the ecology difficult. Flora and fauna across the world are accustomed to their habitat.

This haphazard clearance of forests has forced several of these animals to shift from their native environment. Due to this, several species are finding it difficult to survive or adapt to new habitats.

2. **Increase in global warming**
   Trees play a major role in controlling global warming. The trees utilise the greenhouse gases, restoring the balance in the atmosphere. With constant deforestation the ratio of greenhouse gases in the atmosphere has increased, adding to our global warming woes. Reduced forest means less carbon dioxide is being absorbed by trees, which accumulates in the atmosphere as a result of pollution, acting as a greenhouse gas. At the same time, there may be an increased presence of carbon dioxide if trees are being burnt instead.

3. **Soil Erosion**
   Also due to the shade of trees the soil remains moist. With the clearance of tree cover, the soil is directly exposed to the sun, making it dry.

4. **Floods**
   When it rains, trees absorb and store large amount of water with the help of their roots. When they are cut down, the flow of water is disrupted and leads to floods in some areas and droughts in other.

5. **Loss of biodiversity and wildlife extinction**
   Due to massive felling down of trees, various species of animals are lost. They lose their habitat and forced to move to new location. Some of them are even pushed to extinction. . As there is the high degree of endemism, or presence of species that are only found within a specific geographical region, even localized deforestation can result in loss of species. Our world has lost so many species of plants and animals in the last couple of decades.

6. **Habitat degradation**
   New roads that provide access to settlers and loggers into the forests of Papua New Guinea can cause widespread fragmentation of rainforests. These fragmented landscapes cannot support wildlife the same way intact habitats do.

7. **Disrupted water cycle**
   Deforestation reduces the critical part trees play in the water cycle. When rainfall is reduced in the region, droughts may occur, bringing about major environmental impacts.

Impacts of deforestation in Papua New Guinea
The effects of deforestation on the environment can be classified as direct and indirect. Both direct and indirect effects have the potential to impact upon the health of the people.

Direct effects:
- Soil degradation.
- Silting of waterways and offshore reefs.
- Loss of wildlife habitat and food resources.
- Loss of tourist potential .

- Chemical pollution of soil and water.
- Climatic changes.

Indirect effects:

- Changes in human demography with increases in local population.
- Overtaxing of food, water, and hygiene resource.
- Dislocation of cultural frameworks and social order.
- Downgrading of social values and increase in lawlessness.

Read the article below about the impact of deforestation on Trobriand Forest.

Trobriand Forest 'Dying,' Conservation Director Says

PORT MORESBY: The fast depletion of forest on the Trobriand Islands in Milne Bay province will be an environmental problem in the next 20 years unless it is stopped, Environment and Conservation Director Dr Wari Iamo said. Dr Iamo said the danger is erosion if the rate of intensive gardening is not closely monitored or reforestation is not done quickly. Mr Iamo, who visited the Trobriand Islands at the weekend with Environment and Conservation and Rural Development Minister William Ebenosi, said most part of Kiriwina is now covered in grassland as a result of intensive gardening in the past. Dr Iamo said yam gardening was common and because people could not live without yams which are their staple food and a pride of their culture, they have to make new gardens consequently cutting down more trees. "When all the trees are cut, the danger is soil erosion and even strong winds can sweep the islands bare if there are no trees left," he said. He said what needed to be done now was reforestation in order to save the Islands. Losuia is almost covered in grass except for the few trees left along the coastlines of Kaibola and Waowela beaches. He said yam festivals are part of the people's culture and livelihood and because of such pressure people turn to doing more gardening. Trees are being cut quite often because people do not let a particular bush to rest for at least ten years to recover until a new garden could be made, he said. Dr Iamo said this practice of over using the land could also reduce the fertility of the soil.
The National, August 25, 1999

Solutions to deforestation

1. The best solution to deforestation is to **curb the felling of trees**, by employing a series of rules and laws to govern it. Deforestation in the current scenario may have reduced however it would be too early to assume.
2. **Clear cutting of forests must be banned** will curb total depletion of the forest cover. It is a practical solution and is very feasible.
3. **Land skinned of its tree cover for urban settlements should be urged to plant trees in the vicinity and replace the cut trees**.

Also the cutting of trees must be replaced by planting young trees to replace the older ones that were cut. Trees are being planted under several initiatives every year, but they still do not match the numbers of the ones we have already lost.

It is now time for you to complete Learning Activity 5. Remember, learning activities are not sent in for assessment. However, this learning activity will help you complete Summative Test 1 (which you will send in for assessment)

Learning Activity 5

40 minutes

Answer the following questions.

1. Describe one way by which the following practices may disrupt a food chain or food web:
   i) monoculture
   _____

   ii) use of insecticides
   _____

   iii) use of fertilisers
   _____

2. How do lichens affect the abiotic components of their environments?
   _____
   _____

3. What are some ways in which new plants move to an area?
   _____
   _____

4. What are of the first types of animals to inhabit an area?
   _____
   _____

5. What are some reasons animals move to a new area?
   _____
   _____

Thank you for completing your Learning Activity 5. Check your work. Answers are at the end of this module.

Burning of Fossil Fuels

What are fossil fuels?

Fossil fuels are derivatives of plant and animal remains that are millions of years old. They are organic materials that form over millions of years after dead plants and animals are buried and exposed to extreme pressure and temperature.

Fossil fuels are the major energy sources like coal, oil, and natural gas to help meet the energy and electricity demand of today's world. Many power stations across the world burn fossil fuels to generate energy.

Cars and trucks release carbon monoxide and nitrogen oxides into the atmosphere, which contributes to nutrient pollution in our air and water

Coal is the remains of ancient plants and trees that grew over 200 millions of years ago. **Oil** and **gas** is made up of the remains of microscopic plankton. Over millions of years these remains become carbon-rich coal, oil and gas we use as fue.l

They are non-renewable sources of energy as they are derived from pre-historic fossils and will not be available once they are fully used.

Their sources are limited and they are depleting at a faster rate. Their over consumption can lead to serious environmental issues such as air pollution.

Fossil fuels release carbon dioxide, nitrogen dioxide, sulphur dioxide, carbon monoxide when burnt that can have severe consequences on the habitats.

Dumping of domestic and industrial waste

What is waste and why is it a problem?

Waste, or rubbish, trash, junk, garbage, depending on the type of material, is an unwanted or undesired material or substance. Waste can be regarded as a human concept as there appears to be no such thing as waste in nature.

The problem with fossil fuels and climate change

When fossil fuels are burned they release carbon dioxide. Unless it is captured and stored, this carbon dioxide is usually released to the atmosphere. This leads to increased concentrations of carbon dioxide in the atmosphere.

When fossil fuels are burned, they also release nitrogen oxides into the atmosphere, which contribute to the formation of smog and acid rain. The most common nitrogen-related compounds emitted into the air by human activities are collectively referred to as **nitrogen oxides.**

Ammonia is another nitrogen compound emitted to the air, primarily from agricultural activities, but also from fossil fuels. Most of the nitrogen oxides released due to human activity are from the burning of fossil fuels associated with transportation and industry.

Major sources of nitrogen oxide emissions include:

- Cars and trucks.
- Coal-fired power plants.
- Large industrial operations.
- Ships and airplanes.

Airborne nitrogen pollution affects not only the quality of the air we breathe, but also the land and water.

The presence of excess nitrogen in the atmosphere in the form of nitrogen oxides or ammonia is deposited back onto land, where it washes into nearby water bodies.

These excess nutrients contribute to pollution, harmful algal blooms and oxygen-deprived aquatic zones. Excess ammonia and low pH in these areas are toxic to aquatic organisms and affect their survival.

This increase of atmospheric CO_2 and other gasses has the effect of changing the global climate which contributes to **global warming**. This climate was characterised by higher average global temperatures and higher sea levels.

The changing climate is expected to have extremely grave consequences, leading to an increased number of “extreme” weather events, potential rises in sea level, and possible extinction of plant and animal species due to habitat loss.

The waste products created by a natural process or organism quickly becomes the raw products used by other processes and organisms. It may consist of the unwanted materials left over from a manufacturing process (industrial, commercial, mining or agricultural operations,) or from community and household activities.

The material may be discarded or accumulated, stored, or treated (physically, chemically, or biologically), prior to being discarded or recycled. It is also used to describe something we use inefficiently or inappropriately.

The presence of waste is an indication of overconsumption and that materials are not being used efficiently. This is carelessly reducing the Earths capacity to supply new raw materials

in the future. The capacity of the natural environment to absorb and process these materials is also under stress**.**

Valuable resources in the form of matter and energy are lost during waste disposal, requiring that a greater burden be placed on ecosystems to provide these. The main problem is the sheer volume of waste being produced and how we deal with it.

The following are some of the effects on the population and the environment due to poor management of domestic waste from households.

1. Improper dumping of solid wastes can be an environmental hazard in the surrounding environment that can lead to death of fish as well as **diseases** to man, for example, dysentery and cholera.

2. These wastes when improperly dumped into the atmosphere can lead to the destruction of the ozone layer and may cause diseases such as cancer. As a result there is problem in **global warming**.

3. Waste materials which are toxic if consumed by animals can be very dangerous to life and worse still if these wastes are dumped in water bodies. They are dangerous to aquatic life.

4. Some of these wastes can also be very harmful to the atmosphere. Air pollution can also lead to formation of acidic rain which is dangerous to crop life since it fastens the removal of soil fertility from the surface of the ground.

5. When solid wastes are dumped in drainage channels and gutters, these block the flow of the sewerage. This may cause flooding. At the same time, solid wastes also affect soil drainage which hinders the growing of crops.

How is waste dealt with?

Most contemporary waste management efforts are focused at local government level and based on high technology/ high energy waste disposal by methods such as landfill and incineration. However, these methods are expensive and energy inefficient.

The financial costs of managing long-term environmental impacts of waste disposal are expensive.

Domestic and industrial wastes

The purely environmental costs such as negative effects on habitat, wildlife and biodiversity are also recognized.In other words waste disposal is not sustainable and will have negative implications for future generations.

What can we do?
Appropriate and sustainable approaches to waste need to be adopted. To be sustainable we need to move the emphasis toward a system that is local, community based makes use of low tech / low energy systems and is focused on waste minimization.

Waste minimization is an approach that aims to reduce the production of waste through education and the adoption of improved production processes and less wasteful practices. Waste processing is treatment and recovery (use) of materials or energy from waste through thermal, chemical, or biological means.

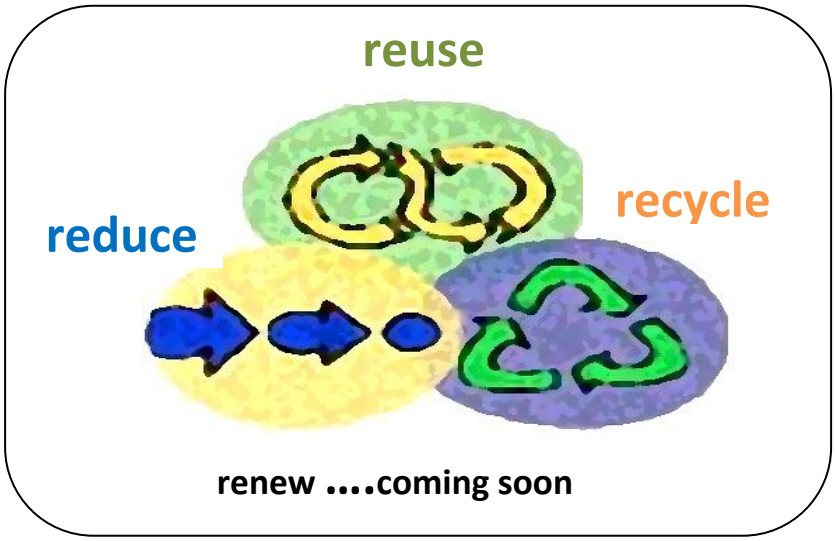
Measures taken in the management of development activities

1. **Implementation of laws**
   The government has enacted legislation to govern biological resources and the environment. This legislation is designed to control pollution which affects the quality of land, air and water.

   For example: Environmental Quality Act, 1974, legislation that governs water quality management in terms of pollution prevention, as well as environment enhancement. Protection of Wildlife Act, 1972 and so on.

2. **Use of technology**
   - Use catalytic converter to clean up exhaust emissions and convert harmful gases released during the combustion of fossil fuels into less harmful products.
   - Use unleaded petrol to reduce the emission of lead into the environment.
   - Treat sewage in sewage treatment plants before it is discharged so as to reduce water pollution.
   - Treat toxic waste produced in factories before discharging it into the environment and so on.

3. **Education on the management of resources**
   - The public must be educated on the importance of protecting and caring for the environment through the mass media and various environmental campaigns.
   - The public must be educated on the concept of the **4Rs**. The 4Rs stand for **recycle**, **reuse, reduce** and **renew**.



The four (4) R's

4. Preservation and Conversation

Preservation involves efforts to protect an ecosystem so that natural resources are utilized in a sustainable manner and the equilibrium of the ecosystem is maintained.

- Sustainable agricultural development is the effective use and preservation of soil to ensure continuous agricultural production**.**
- Clean water is a precious resource and commodity. As such, water sources and water catchment areas must be preserved**.**

Conservation involves efforts to return an affected ecosystem to its natural equilibrium.

- The sustainable use of forests is important to strike a balance between continuous harvesting of forest products, and at the same time maintaining the environmental services of forests (afforestation).
- Reforestation is to ensure that forests where logging activities have been carried out are not damaged and that the forests continue to be productive and able to support the diversity of lives.

5. The practice of biological control

Biological control is the use of natural predators to control the population of pest species. It is better than using chemical control which involves the use of pesticides. This is because:

- pesticides are not always selective and sometimes kill pesticides are not always selective and sometimes kill harmless organisms as well as the pest species.
- may be persistent and remain in the environment for long periods.
- the extensive use of pesticides pollutes the environment.
- pest develop resistance, hence a higher dose of pesticides is required to produce a similar effect is required to produce a similar effect.

- as a result high pesticides caused biomagnification, may accumulate in the tissues of final consumers. These pesticides may be toxic and may affect the metabolism of the consumers.

Some examples of biological control are:

1. The use of caterpillars of the species *Cactoblastis cactorum* to control the prickly pear cactus which spreads quickly and invades farming land.

Cactoblastis cactorum caterpillars on a leaf.

2. The use of hoverfly larvae to control aphids which feed on crop plants.

Hoverfly larvae eating aphid

3. The use of owls to control the population of rats in oil palm plantations.

Owls in oil palm plantation

6. The use of renewable energy

Renewable energy is the energy flow that occurs naturally in the environment and can be used for the benefit of human. It is inexhaustible and does not pollute benefit of human.

Examples of renewable energy are:

Geothermal energy. Flowing water generates hydroelectric power.

Wind energy operates windmills to pump water for irrigation of crops

Biomass energy produced when decomposing organic matter release gas.

Wave energy. The motion of waves which is used to generate energy.

Solar energy is converted into electricity and used in heating.

7. The efficient use of energy

- Reduce burning of coal, petroleum and other fossil fuels.
- Use cleaner fuel by reducing the content of sulphur in diesel and switching to gas.
- Substitute natural gas for coal at power plants.
- Improve energy efficiency in factories.
- Improve fuel efficiency in vehicles-use cars that have energy-efficient engines.
- Use more hybrid cars which combine electric and gasoline engines.

REVISE WELL USING THE MAIN POINTS ON THE NEXT PAGE

SUMMARY

You will now revise this module before doing **SUMMATIVE TEST 1**. Here are the main points to help you revise. Refer back to module topics if you need more information.

- Biology in general is the study of living things.
- The branch of biology that deals with the study of the interactions among organisms and with their environment is known as ecology. It explains how living organisms affect each other and the world they live in.
- Ecologists have organised the interactions an organism takes part in into different levels according to complexity.
    - **Organism** is any form of life
    - **Species** is groups of organisms that resemble one another in appearance, behaviour, chemistry and genetic structure form a species.
    - **Population** is group of organisms, all of the same species.
    - **Community** is all the populations in an ecosystem.
    - **Ecosystem** is a community of organisms involved in a dynamic network of biological, chemical and physical interactions between themselves and with the nonliving components.
- Biosphere can be defined as the sum total of all organisms and their habitats.
- Habitat is the place a plant or animal lives.
- The three major climate zones are **polar**, **temperate** and **tropical** zones.
- **Ecosystem** is a system of living things that interact with each other and with the physical world.
- There are two major components in the ecosystem that influence plant and animal life, abiotic and biotic factors.
- **Abiotic factors** are the non-living components of a habitat which include amount of water and oxygen, temperature, amount of sunlight and water pressure.
- **Biotic factors** are all the living organisms that inhabit an environment. All organisms depend on others directly or indirectly for food, shelter, reproduction, or protection.
- A complex community of plants and animals in a region and a climate is called a **biome**. A **biome** is a collection of related ecosystems.
- Some of the biomes on Earth include; desert tropical rainforest, taiga or coniferous forest, chaparral or scrub, grassland, and tundra.
- Organisms of different species in a community do not stay in isolation from each other, and hence community ecology is concerned with the variety of interactions that take place between the various species. These interactions include: **competition**, **mutualism**, **predation, commensalism**, **parasitism**.
- Living organisms (biotic components) in an ecosystem can be classified as either **producers** or **consumers**, depending on how they get their food.
- The **flow of energy** is the most important factor that controls what kinds of organisms elive in an ecosystem.

- A **food chain** shows the feeding relationship between different living things in a particular environment or habitat.
- Food chains may be interconnected to form a **food web**.
- The relationship between producers and consumers can be demonstrated through **ecological pyramids.**
- **Ecological pyramids** are models that show how energy flows through ecosystems and are the graphic representations of trophic levels in an ecosystem.
- An **energy pyramid** represents the energy available for each trophic level in an ecosystem.
- **Pyramid of numbers** represents the number of individual organisms available for energy at each trophic level in an ecosystem.
- A biomass pyramid represents the total mass of living organic matter (biomass) at each trophic level in an ecosystem.
- **Biomagnification** is the process in which pollutants become more and more concentrated in living tissue.
- **Eutrophication** is the process in which the levels of water nutrients become too high, eventually causing dissolved oxygen levels in the water to become too low.
- Members of an ecological community depend on the exchange of resources in continual cycles. **Cycles** within an ecosystem intersect with larger regional and global cycles.
- This cycling of materials includes the **oxygen-carbon dioxide cycle**, the **water cycle**, and the **nitrogen cycle**.
- **Ecosystem succession** also called **ecological succession** is the process through which a natural community of plants and animals changes after a disturbance.
- There are two basic types of ecological succession, which are categorised mainly based on how many nutrients or lack thereof are already present in the soil after the disturbance.
    - **Primary ecosystem succession** is when a community first forms in a newly created or exposed area such as a sand dune or bare rock surface, lava flow, or a new lake created by flooding.
    - **Secondary succession** is when a community was disturbed by human or elemental forces. It begins after an event clears the community but leaves the soil intact.
- Humans are one animal species involved in these processes that have a great impact on the flow of energy and the cycling of matter. Human influence on balance in the biosphere can be positive (example a helpful technology) or negative (example, pollution) and intentional or unintentional.
- Humans are the top consumers in many food pyramids. To increase food production, they use methods that have an effect on food chains and food webs. Some of the farming practices are described as follows:
    - **Monoculture** is a practice that has allowed many technological advances in crop production. Having only one crop in the field increases our ability to mechanize planting, weeding, and harvest.
    - Farmers spray their crops with **insecticides** to kill insect pests, and with herbicides to kill weeds.

  - Monocrops usually require large amounts of **chemical fertilisers**. Continuous and uncontrolled use of chemical fertilisers may increase soil acidity, thus destroying soil structure.
- Humans have always practiced **deforestation** throughout history.
- The causes of deforestation are:
  - Agricultural activities.
  - Logging.
  - Urbanization.
  - Desertification of land.
  - Mining.
  - Forest fire.
- Effects of deforestation are as the following:
  - Climate imbalance.
  - Increase in global warming.
  - Soil Erosion.
  - Floods.
  - Loss of biodiversity and wildlife extinction.
  - Habitat degradation.
  - Disrupted water cycle.
- **Fossil fuels** are derivatives of plant and animal fossils that are millions of years old. They are organic materials that form over millions of years after dead remains of plants and animals are buried and exposed to extreme pressure and temperature.
- **Coa**l is the remains of ancient plants and trees that grew over 200 millions of years ago.
- **Oil** and **gas** is made up of the remains of microscopic plankton.
- The increase of atmospheric CO_2 and other gasses has the effect of changing the global climate which contributes to global warming. This climate was characterized by higher average global temperatures and higher sea levels.
- Measures taken in the management of development activities are as follows:
  - Implementation of laws.
  - Use of technology.
  - Education on the management of resources.
  - Preservation and Conversation.
  - The practice of biological control
  - The use of renewable energy.
  - The efficient use of energy.

NOW DO SUMMATIVE TEST 1 IN YOUR ASSESSMENT BOOK AND SEND IN TO THE PROVINCIAL COORDINATOR FOR MARKING.

ANSWERS TO LEARNING ACTIVITIES 1- 5

Learning Activity 1

A.

1. Ecology is the branch of biology that deals with the study of the interactions among organisms and with their environment.
   Ecologists are scientists who study ecology
   Ecosystem is a system of living things that interact with each other and with the physical world.

B.

1. c
2. a
3. e
4. b
5. d

Learning Activity 2

1. Prickly pear cactus, Harris's antelope squirrel, diamondback rattlesnake, coyote, a roadrunner, Red-tailed hawk

2. Prickly pear cactus

3. fruit

4.

Producer/s	1st Order Consumer/s	2nd Order Consumer/s
prickly pear cactus	harris antelope squirrel	diamondback rattlesnake

5. Energy from the sun → Prickly pear cactus → squirrel → rattlesnake

   Producer — 1st order consumer — 2nd order consumer

6. (Any one answer is accepted)
   A food chain shows the feeding relationship between different living things in a particular environment or habitat.
   A food chain represents a series of events in which food and energy are transferred from one organism in an ecosystem to another.
   Food chains show how energy is passed from the sun to producers, from producers to consumers, and from consumers to decomposers.
   Food chain is a process when one organism is eaten by the other.

Learning Activity 3

1. 500 kg biomass of humans.

2. Corn can support 500 kg biomass of chicken.

3. Chicken can support 50kg biomass of human.

4. A plant eater is more efficient because it directly receives more of biomass from the producer.

Learning Activity 4

1. A. Respiration B. Photosynthesis C. Respiration
   D. Combustion E. Feeding F. Death

2. A. Respiration B. Combustion

3. 1

4. In the form of carbohydrates

5. When an animal or a plant dies, it can either be respired by decomposers (or released to the atmosphere), or it can be buried intact and ultimately form coal, oil, or natural gas (fossil fuels).

Learning Activity 5

1. i) monoculture
   By limiting the cultivation of different kinds of plants, people also deprive many animals of their food and home.

ii) use of insecticides
Insecticides move up the food pyramid and accumulate in the body of organisms. The smallest concentration of the chemical is at the base of the pyramid occupied by producers.

iii) use of fertilisers
Continuous and uncontrolled use of chemical fertilisers may increase soil acidity, thus destroying soil structure. Findings show that more fertilisers are needed for the same amount of yield after years .

2. Lichens cause chemical weathering by secreting an acid into the rock that causes the rock to soften. The surface of the rock may then slowly break down and create a shallow layer of sediment.

3. Seeds brought by birds, wind, or water may settle in this sediment, grow for a short period of time, die, and add nutrients to the soil. Insects and other small animals may come to the area to feed on the small plants and other insects that live there. In turn these animals will contribute to the collection of nutrients in the sediment which has begun to turn into a richer, more fertile soil that can support larger plants.

4. Simple plants, fungi, lichens, or other microscopic organisms begin to inhabit bare rock or other lifeless areas.

5. Animals then become attracted to the area because of the new wealth of food, both plant and animal.

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University of the Philippines National Institute for Science and Mathematics Education

26 Module E1 Ecology

Student Support Material

Figure 6. An illustration of the carbon cycle. Adapted from New Biology for Tropical

Schools

By Victoria Wilson (October 17,2014)

deforestation_wideweb__470x297,0.jpg

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FODE PROVINCIAL CENTRES CONTACTS

PC NO.	FODE PROVINCIAL CENTRE	ADDRESS	PHONE/FAX	CUG PHONE (COORDINATOR)	CUG PHONE (SENIOR CLERK)
1	ALOTAU	P. O. Box 822, Alotau	6411343/6419195	72228130	72229051
2	BUKA	P. O. Box 154, Buka	9739838	72228108	72229073
3	CENTRAL	C/- FODE HQ	3419228	72228110	72229050
4	DARU	P. O. Box 68, Daru	6459033	72228146	72229047
5	GOROKA	P. O. Box 990, Goroka	5322085/5322321	72228116	72229054
6	HELA	P. O. Box 63, Tari	73197115	72228141	72229083
7	JIWAKA	c/- FODE Hagen		72228143	72229085
8	KAVIENG	P. O. Box 284, Kavieng	9842183	72228136	72229069
9	KEREMA	P. O. Box 86, Kerema	6481303	72228124	72229049
10	KIMBE	P. O. Box 328, Kimbe	9835110	72228150	72229065
11	KUNDIAWA	P. O. Box 95, Kundiawa	5351612	72228144	72229056
12	LAE	P. O. Box 4969, Lae	4725508/4721162	72228132	72229064
13	MADANG	P. O. Box 2071, Madang	4222418	72228126	72229063
14	MANUS	P. O. Box 41, Lorengau	9709251	72228128	72229080
15	MENDI	P. O. Box 237, Mendi	5491264/72895095	72228142	72229053
16	MT HAGEN	P. O. Box 418, Mt. Hagen	5421194/5423332	72228148	72229057
17	NCD	C/- FODE HQ	3230299 ext 26	72228134	72229081
18	POPONDETTA	P. O. Box 71, Popondetta	6297160/6297678	72228138	72229052
19	RABAUL	P. O. Box 83, Kokopo	9400314	72228118	72229067
20	VANIMO	P. O. Box 38, Vanimo	4571175/4571438	72228140	72229060
21	WABAG	P. O. Box 259, Wabag	5471114	72228120	72229082
22	WEWAK	P. O. Box 583, Wewak	4562231/4561114	72228122	72229062

FODE SUBJECTS AND COURSE PROGRAMMES

GRADE LEVELS	SUBJECTS/COURSES
Grades 7 and 8	1. English
	2. Mathematics
	3. Personal Development
	4. Social Science
	5. Science
	6. Making a Living
Grades 9 and 10	1. English
	2. Mathematics
	3. Personal Development
	4. Science
	5. Social Science
	6. Business Studies
	7. Design and Technology- Computing
Grades 11 and 12	1. English – Applied English/Language& Literature
	2. Mathematics – General/Advance
	3. Science – Biology/Chemistry/Physics
	4. Social Science – History/Geography/Economics
	5. Personal Development
	6. Business Studies
	7. Information & Communication Technology

REMEMBER:

- For Grades 7 and 8, you are required to do all six (6) subjects.
- For Grades 9 and 10, you must complete five (5) subjects and one (1) optional to be certified. Business Studies and Design & Technology – Computing are optional.
- For Grades 11 and 12, you are required to complete seven (7) out of thirteen (13) subjects to be certified.

Your Provincial Coordinator or Supervisor will give you more information regarding each subject and

Notes: You must seek advice from your Provincial Coordinator regarding the recommended courses in each stream. Options should be discussed carefully before choosing the stream when enrolling into Grade 11. FODE will certify for the successful completion of seven subjects in Grade 12.

GRADES 11 & 12 COURSE PROGRAMMES			
No	**Science**	**Humanities**	**Business**
1	Applied English	Language & Literature	Language & Literature/Applied English
2	Mathematics -General/Advance	Mathematics -General/Advance	Mathematics –General/Advance
3	Personal Development	Personal Development	Personal Development
4	Biology	Biology/Physics/Chemistry	Biology/Physics/Chemistry
5	Chemistry/ Physics	Geography	Economics/Geography/History
6	Geography/History/Economics	History / Economics	Business Studies
7	ICT	ICT	ICT

CERTIFICATE IN MATRICULATION STUDIES		
No	**Compulsory Courses**	**Optional Courses**
1	English 1	**Science Stream:** Biology, Chemistry, Physics
2	English 2	**Social Science Stream:** Geography, Intro to Economics and Asia and the Modern World
3	Mathematics 1	
4	Mathematics 2	
5	History of Science & Technology	

REMEMBER:

You must successfully complete 8 courses: 5 compulsory and 3 optional.