A PUBLICATION FOR THE MIDDLE SCHOOLS OF THE REPUBLIC OF SENEGAL
APPROVED BY THE MINISTRY OF EDUCATION

Introduction to Life Science and Earth Science

Grades 9 and 10

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Part I: Planet Earth's Biosphere and Environment

Lesson 1: Planet Earth's Biosphere and Our Solar System

Do You Know?

Planet Earth is the third planet from the Sun in our Solar System. It is the planet on which we live. It is the planet we call our home. **Planet Earth is the only known planet where life exists and life can survive, as we know it.** As far as we know, there is no other planet in the universe with an environment like planet Earth. For example on planet Earth there is a very narrow temperature range that allows water (H_2O) to remain a liquid. Life has developed over millions of years because of this liquid we call water and other factors. What else makes planet Earth special? Planet Earth has an atmosphere consisting primarily of nitrogen, a relatively inert gas. If planet Earth's atmosphere consisted primarily of sulfuric acid or methane, life may never have developed on planet Earth.

Many other factors affect the biosphere and life on planet Earth. There are large factors such as the distance between the Earth and the Sun. If our planet were closer to the Sun, it might be too hot to support life. If we were further away, it might be too cold.

Some smaller factors also affect the biosphere and life on planet Earth. If one were to critically an area of land that is only one square mile, one might find influential factors such as climate, daily weather, and erosion. These smaller factors change the land and affect the organisms that exist in that area of land. Even though humans are able to control their environment, they are still vulnerable to weather and things like earthquakes.

The smallest of factors that affect the biosphere and life on Earth occur at the molecular level. **Chemical erosion** is an example of land changing one molecule at a time. **Oxidation** and **reduction** reactions happen all the time, changing the composition of rocks and organic materials. The smallest of factors involve not just chemistry at work on the molecular level but tiny organisms as well. Tiny organisms such as bacteria and single-celled organisms are constantly working to break down materials (organic and inorganic) and change planet Earth.

In this lesson one can learn many fascinating things about plant Earth's biosphere and Solar System.

Planet Earth's Biosphere and Our Solar System

The biosphere is all about life on planet Earth. Physical geographers use the term **biosphere** to describe our living world. This is where all organisms: the trees, bugs, germs, microorganisms, small plants and large animals live. The biosphere extends to the upper areas of the atmosphere where birds and insects can be found. It goes deep into the ground in dark caves where tiny organisms live or to the bottom of the ocean. The biosphere extends to any place that life (of any kind) can or does exist on planet Earth.

The biosphere is the one place where all of the other spheres or environments on planet Earth work together. The land (lithosphere) interacts with the water (hydrosphere). The land interacts with the air (atmosphere). The land even interacts with forces deep inside planet Earth and with the energy coming to planet Earth from the Sun. All of those forces and others work together to create and sustain life on planet Earth.

The term **"Biosphere"** was introduced by a Russian scientist name Vladimir Vernadsky in the 1929. The biosphere is the life zone of planet Earth and includes all living organisms, including man, and all organic matter that has not yet decomposed. Life evolved on earth during its early history between 4.5 and 3.8 billion years ago and the biosphere readily distinguishes our planet from all others planets known to man; especially, those in our Solar System. The chemical reactions of life (e.g., photosynthesis-respiration, carbonate precipitation, etc.) have also created a strong signal on the chemical composition of the atmosphere, transforming the atmosphere to an oxidizing environment with free oxygen. The biosphere can be viewed as a hierarchy known as the food chain whereby all life is dependent upon the first tier of this hierarchy (i.e. mainly the primary producers that are capable of photosynthesis). Energy and mass is transferred from one level of the food chain to the next with an efficiency of about 10%. All organisms are intrinsically linked to their physical environment and the relationship between an organism and its environment is the study of ecology. The biosphere can be divided into distinct ecosystems that represent the interactions between a group of organisms and the environment or habitat in which they live.

Some life scientists and earth scientists use *biosphere* in a more limited sense. For example, geochemists define the biosphere as being the total sum of living organisms. In this sense, the biosphere is but one of four separate components of the geochemical model, the other three being *lithosphere*, *hydrosphere*, and *atmosphere*.

Nearly every part of the planet, from the polar ice caps to the Equator, supports life of some kind. Recent research in microbiology have demonstrated that microbes live deep beneath the Earth's terrestrial surface, and that the total mass of microbial life in so-called "uninhabitable zones" may, in biomass, exceed all animal and plant life on the surface. Microscopic organisms live in such extremes places that, taking them into consideration puts the range of the biosphere much greater, extending from a minimum of 5,400 meters above sea level to at least 9,000 meters below sea level.

Planet Earth's Biosphere and Our Solar System

Planet Earth and the Solar System


Solar System -The Sun and the nine planets

The Sun is a star. A **star** is a massive, glowing ball of plasma. The nearest star to planet Earth is the Sun, which is the source of most of the energy on Earth. Other stars are sometimes visible in the night sky. A star shines because nuclear fusion inside the star releases radiation that passes from the star's interior and then radiates into outer space. Almost all elements heavier than hydrogen and helium were created inside the interior of stars. A **planet** is defined by the International Astronomical Union (IAU) as a celestial body orbiting a star or stellar remnant; it is massive enough to have its own gravity but not massive enough to cause thermonuclear fusion in its interior.

Earth is the third planet from the Sun in distance and the fifth largest in our solar system. Of the four terrestrial planets closest to the Sun, Earth is the largest and has the most mass. Earth's density is the greatest of the nine planets in our solar system. Our **Solar System** consists of a central star we call the **Sun** and nine planets orbiting it. The planets that orbit the Sun are **Mercury**, **Venus**, **Earth**, **Mars, Jupiter, Saturn, Uranus, Neptune,** and **Pluto**. The Solar System also includes the satellites of the planets; numerous comets, asteroids, and meteoroids; and the interplanetary medium. The planets and their satellites orbit the Sun in or near a circular direction. When looking down from above the Sun's north pole, the planets orbit in a counter-clockwise direction.

The Sun's nearest known stellar neighbor is a red dwarf star called **Proxima Centauri**, which is a distance of 4.3 light years away. The whole Solar System, together with the local stars visible on a clear night, orbits the center of our home galaxy, a spiral disk of 200 billion stars that we call the **Milky Way**. The Milky Way has two small galaxies orbiting it nearby, which are visible from the southern hemisphere. They are called the **Large Magellanic Cloud** and the **Small Magellanic Cloud**. The nearest large galaxy is the **Andromeda Galaxy**. It is a spiral galaxy like the Milky Way but is 4 times as massive and is 2 million light years away. Our galaxy, one of billions of galaxies known, is traveling through intergalactic space. A **galaxy** is a massive, gravitationally bound system consisting of stars, an interstellar medium of gas and dust, and dark matter. Typical galaxies range from small ones with as few as ten million stars up to giants with one trillion stars, all orbiting a common center of mass.

The **terrestrial planets** are the four innermost planets in the solar system, Mercury, Venus, Earth and Mars. They are called terrestrial because they have a compact, rocky surface like the Earth's. The planets, Venus, Earth, and Mars have significant atmospheres while Mercury has almost none. Jupiter, Saturn, Uranus, and Neptune are known as the **Jovian (Jupiter-like) planets,** because they are all gigantic, compared with Earth, and are gaseous in nature like Jupiter (g*as giants, some with s*mall solid cores).

Planet Earth's Biosphere and Our Solar System

Size and shape of the four terrestrial planets (left - right): Mercury, Venus, Earth, and Mars

The Earth's shape is very close to a sphere - a rounded shape with a bulge around the equator - although the precise shape varies. The average diameter of planet Earth is about 12,742 km. The **equator** is one of the five main circles of latitude that are based on the relationship between the Earth's axis of rotation and the plane of the Earth's orbit around the Sun. It is the only line of latitude which is also a great circle. The imaginary circle obtained when the Earth's equator is projected onto the heavens is called the celestial equator. The Sun, in its seasonal movement through the sky, passes directly over the equator twice each year, in the March and September. At the equator, the rays of the sun are perpendicular to the surface of the earth at these times. Places on the equator experience the quickest rates of sunrise and sunset in the world. Such places also have a constant 12 hours of day and night throughout the year, while north or south of the equator day length increasingly varies with the seasons.

Th**e Moon** can be seen on clear days or nights from anywhere on the surface of Earth if you know when to look. The Moon is the Earth's only natural satellite. The Moon is about 384,403 kilometers from Earth, and has an approximate diameter of 3,476 km. The Moon makes one full orbit around the Earth every 29.5 days. During this period the Moon enters a series of phases, which changes the amount of light reflected off its surface and its visible shape to the naked eye from Earth. Exploration of the moon began in 1959 when the unmanned Luna 2 landed on its surface. Luna 3 closely followed Luna 2 in late 1959, which obtained the first images of the far side of the moon. Humans first landed on the Moon aboard Apollo 11 on that historic night in 1969. Earth's ocean tides are initiated by the *tidal force* of the Moon's gravity and are magnified by a host of effects in Earth's oceans The Moon also has other effects on planet Earth's biosphere.

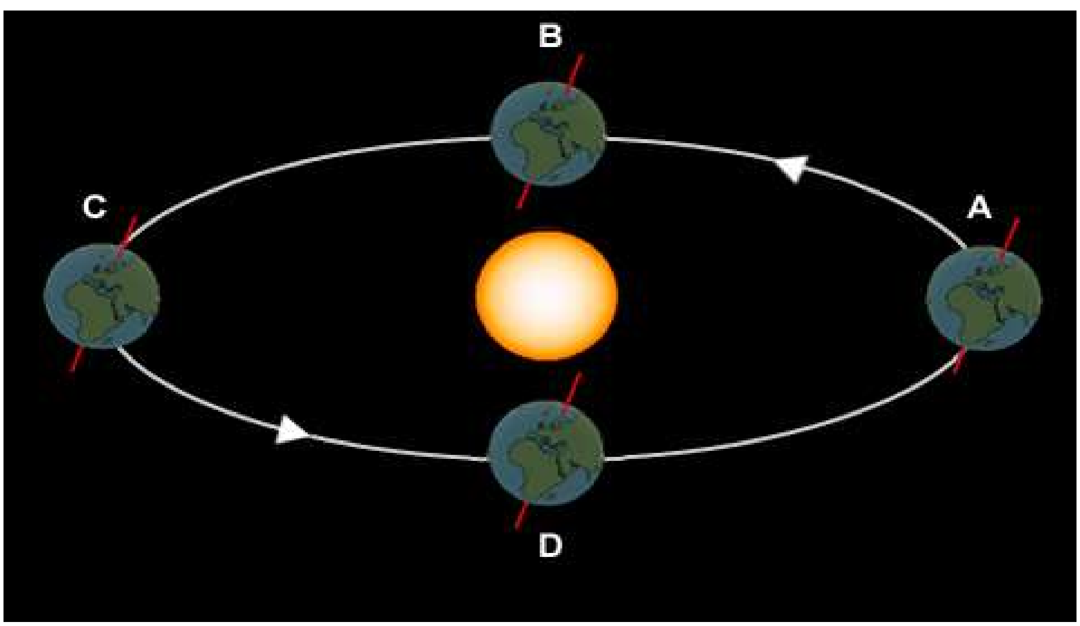
Planet Earth's Biosphere and Our Solar System

The Moon

The Moon orbiting around the Earth

A Galaxy

The Earth rotates about its axis once each day, the Moon orbits the Earth once each month, and the Earth orbits the Sun once each year. All of these rotations affect the time, (hours) each day, when we have day time and night time, what seasons we have, the tides in the oceans each day, the climate, and the weather; as well as other factors on Earth. **Seasons** and seasonal climate changes are direct results of the tilt of the Earth towards or away from the Sun.



The Earth orbiting around the Sun and rotating about it's axis

Part I: Planet Earth's Biosphere and Environment

Lesson 2: Planet Earth's Environment: Atmosphere (Air), Lithosphere (Land), Hydrosphere (Water)

Do You Know?

Atmosphere: Life processes involve a vast number of chemical reactions some of which either obtain or provide gases from and to the atmosphere. For example, photosynthesis consumes carbon dioxide and produces oxygen whereas respiration does the opposite. Other examples of biogenic gases in the atmosphere include methane, dimethylsulfide (DMS), nitrogen, nitrous oxide, ammonia, etc.).

Hydrosphere: Water is essential for all living organisms on Earth and has played a key role in the evolution and sustaining of life on planet Earth. The biosphere as we know it would not exist without liquid water (for example, consider Mars). Water is also important for transport the soluble nutrients (phosphate and nitrate) that are needed for plant growth, and for transporting the waste products of life's chemical reactions.

Lithosphere: Land, the outer solid part of the earth, including the crust and uppermost mantle. The lithosphere is about 100 km thick, although its thickness is age dependent (older lithosphere is thicker).The lithosphere below the crust is brittle enough at some locations to produce earthquakes by faulting, such as within an oceanic plate. It is on and within the lithosphere where much of life on earth exist. It is here that one finds the soil and minerals which are so important for helping to sustain life on Earth.

Geosphere: The geosphere and biosphere are intimately connected through soils, which consist of a mixture of air, mineral matter, organic matter, and water. In fact, one could consider soil as composed of all four spheres (atmosphere, geosphere, biosphere, and hydrosphere). Plant activity such as root growth and generation of organic acids are also important for the mechanical and chemical breakdown (weathering) of the geosphere.

Anthrosphere: Human population poses a threat to the biosphere by habitat destruction, especially by the destruction of tropical rainforests (deforestation). This process is driving thousands of species each year to extinction and reducing biological diversity.

In this Lesson one can learn one can learn many details about Earth's environment where Life Science and Earth Science are dependent on one another.

Planet Earth's Environment: Atmosphere (Air), Lithosphere (Land), Hydrosphere (Water)

Atmosphere

The Earth's atmosphere consists, from the ground up, the **troposphere**, **stratosphere**, **mesosphere**, **thermosphere** (ionosphere), **exosphere** and the **magnetosphere**. **Three quarters of the atmosphere lies within the troposphere.** The atmosphere is the gasesous envelope that surrounds planet Earth and constitutes the transition between its surface and the vacuum of space. The atmosphere consists of a mixture of gases composed primarily of nitrogen, oxygen, carbon dioxide, and water vapor. It extends some 500 km above the surface of the Earth and the lower level – the **troposphere,** constitutes the climate system that maintains the conditions suitable for life on the planet's surface. The next atmospheric level, the **stratosphere** (12 to 48 km), contains the **ozone layer** that protects life on the planet by filtering harmful ultraviolet radiation from the Sun. Since the Industrial Revolution, man has been altering the composition of the atmosphere by the burning of fossil fuels. Concern has been growing about rising concentrations of carbon dioxide, methane, nitrous oxide, and chloroflurocarbons in the atmosphere because these "greenhouse" gases trap heat energy emitted from the earth surface and increase global temperatures (global warming). Also chloroflurocarbons are effective at depleting the Earth's ozone shield that protects the earth surface from the harmful effects of ultraviolet radiation. The **mesosphere** is the layer of the Earth's atmosphere that is directly above the stratosphere. The mesosphere is located from about 50 km to 80-90 km altitude above Earth's surface. The **thermosphere** is the layer of the earth's atmosphere directly above the mesosphere. The **exosphere** is the uppermost layer of the atmosphere above the thermosphere. It is only from the exosphere that atmospheric gases, atoms, and molecules can, to any appreciable extent, escape into space. The **magnetosphere** of Earth is a region in space whose shape is determined by the extent of Earth's internal magnetic field, the solar wind plasma, and the interplanetary magnetic field (IMF).

Planet Earth's Environment:
Atmosphere (Air), Lithosphere (Land), Hydrosphere (Water)

Lithosphere

The concept of the lithosphere as Earth's strong outer layer was developed by Barrell, who wrote a series of papers introducing the concept (Barrell 1914a-c). The concept was based on the presence of significant gravity anomalies over continental crust, from which he inferred that there must exist a strong upper layer (which he called the lithosphere) above a weaker layer which could flow (which he called the asthenosphere). These ideas were enlarged by Daly (1940), and have been broadly accepted by geologists and geophysicists. Although these ideas about lithosphere and asthenosphere were developed long before plate tectonic theory was articulated in the 1960's, the concepts that strong lithosphere exists and that this rests on weak asthenosphere are essential to that theory.

The division of Earth's outer layers into lithosphere and asthenosphere should not be confused with the chemical subdivision of the outer Earth into mantle (the **Mantle** is a part of the approximate ~2,900 km thick rocky shell comprising approximately 70% of Earth's volume), and the crust (the **crust** is the outermost solid shell of a planet or moon, crust is chemically and mechanically different from underlying material). All crust is in the lithosphere, but lithosphere generally contains more mantle than crust.

There are two types of lithosphere:

- Oceanic lithosphere, which is associated with Oceanic crust
- Continental lithosphere, which is associated with Continental crust

Oceanic lithosphere is typically about 50-100 km thick (but beneath the mid-ocean ridges is no thicker than the crust), while continental lithosphere has a range in thickness from about 40 km to perhaps 200 km; the upper ~30 to ~50 km of typical continental lithosphere is crust. The mantle part of the lithosphere consists largely of peridotite (**peridotite** is a dense, coarse-grained molten rock, consisting mostly of the minerals olivine and pyroxene). The crust is distinguished from the upper mantle by it's chemical composition..

Oceanic lithosphere consists mainly of crust and mantle peridotita crust and is denser than continental lithosphere, for which the mantle is associated with crust made of felsic rocks. Oceanic lithosphere is much younger than continental lithosphere: the oldest oceanic lithosphere is about 170 million years old, while parts of the continental lithosphere are billions of years old. Another distinguishing characteristic of the lithosphere is its flow properties. the lithosphere responds essentially as a rigid shell and thus deforms primarily through brittle failure, whereas the asthenosphere (the layer of the mantle below the lithosphere) is heat-softened and accommodates strain through plastic deformation.

It is on and within the lithosphere where life on Earth exists on land.

Planet Earth's Environment:
Atmosphere (Air), Lithosphere (Land), Hydrosphere (Water)

Hydrosphere

The hydrosphere includes all water on Earth. The surface, 71%, of planet Earth is covered by water and only 29% is land. Indeed, the abundance of water on Earth is a unique feature that clearly distinguishes our "Blue Planet" from others in the solar system. **Not a drop of liquid water can be found anywhere else in the solar system**. It is because the Earth has just the right mass, the right chemical composition, the right atmosphere, and is the right distance from the Sun (the "Goldilocks" principle) that temperatures and pressures of our planet permit water to exist in all three states: solid (ice), liquid (water), and gas (water vapor). Most of the water is contained in the oceans and the high heat capacity of this large volume of water (1.35 million cubic kilometers) buffers the Earth surface from large temperature changes such as those observed on the moon. Water is the universal solvent and the basis of all life on planet Earth. It is an essential life-sustaining resource for all life on Earth. Water re-cycles between the various components of the Earth systems by what is known as the hydrologic cycle or water cycle. Atmosphere: Water is transferred between the hydrosphere and biosphere by evaporation and precipitation. Energy is also exchanged in this process. Biosphere: Terrestrial plants withdraw water from the ground using their root systems and transport water and nutrients through the vascular system to stems and leaves. Evaporation of water from the leaf surface (called transpiration) is effective at transferring water to the atmosphere. Lithosphere or Geosphere (land): Water is the primary agent for the chemical and mechanical breakdown of rock, called weathering, to form loose rock fragments (regolith) and soil. By the process of erosion, water changes the surface of the Earth as precipitation that falls on the land makes it way by to the sea. The Earth is unique because of running water. Human activity has significantly impacted the supply and quality of water on Earth through our agricultural and industrial practices. Chemical contamination of groundwater, lakes, rivers, and the oceans is threatening the quality of the water supply in many parts of the world.

Part I: Planet Earth's Biosphere and Environment

Lesson 3: Ecology and Distinct Ecosystems - Biomes

Do You Know?

Ecology is a science all by itself but it is also a branch of the larger sciences: Life Science and Earth Science. **Ecology** is the study of organisms and the environments they live. Ecologists do not just study a fish. They study the fish, water, sunlight, food supply, things that eat the fish, and every possible factor that might affect the fish in its lifetime. Ecologists study specific areas of biological activity called ecosystems.

The details and complexities of ecosystems make ecology interesting. Ecologists first study all of the interactions inside of the ecosystem. They then apply the idea that no ecosystem (local environment) exists alone. Ecosystems interact with each other. That lake is interacting with the surrounding land. The surrounding land interacts with the ecosystem of the organisms that live on it. The first principle of ecology is that each living organism has an ongoing and continual relationship with every other element that makes up its environment. An **ecosystem** can be defined as any situation where there is interaction between organisms and their environment.

Within an ecosystem, species are connected by food chains, Energy from the sun, captured by primary producers via photosynthesis, flows upward through the chain to **primary consumers (herbivores)**, and then to **secondary and tertiary consumers (carnivores and omnivores)**, before ultimately being lost to the system as waste heat. In the process, matter is transported from one living organism to the next, which return their nutrients to the system via decomposition, forming biogeochemical cycles such as the carbon and nitrogen cycles.

The concept of an ecosystem can apply to units of variable size, such as a pond, a field, a piece of dead wood. *an ecosystem can be a stone and all the life under it, a forest, and a a whole eco region, with its drainage basin.* The following large ecosystems may be defined:

- As **continental ecosystems,** such as forest ecosystems, meadow ecosystems such as steppes or savannas, or agro-ecosystems.
- As **ecosystems of inland waters**, such as lakes or ponds; or such as rivers.
- As **oceanic ecosystems;** also the **human ecosystem**.

Biomes are unique situations. They are very specialized ecosystems that only exist in certain parts of the world: rainforests, deserts, tundra, etc.

In this lesson one can learn many things about ecosystems.

Ecology and Distinct Ecosystems - Biomes

Ecology - The Study of Ecosystems, Biomes

Ecology is a science all by itself but it is also a branch of the larger sciences: Life Science and Earth Science. **Ecology** is the study of organisms and the environments they live in. As an ecologist, you don't just study a fish. You study the fish, water, sunlight, food supply, things that eat the fish, and every possible factor that might affect the fish in its lifetime. Ecologists study specific areas of biological activity called ecosystems.

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- As **oceanic ecosystems**.

Another classification can be done by reference to its communities, such as in the case of an human ecosystem.

Dynamics and stability of Ecosystems

Ecological factors which affect dynamic change in a population or species in a given ecology or environment are usually divided into two groups: abiotic and biotic.

Abiotic factors are geological, geographical, hydrological and climatological parameters. A **biotope** is an environmentally uniform region characterized by a particular set of abiotic ecological factors. Specific abiotic factors include:

- Water, which is at the same time an essential element to life and a milieu
- Air, which provides oxygen, nitrogen, and carbon dioxide to living species and allows the dissemination of pollen and spores

Ecology and Distinct Ecosystems - Biomes

- Soil, at the same time source of nutriment and physical support
    - Soil pH, salinity, nitrogen and phosphorus content, ability to retain water, and density are all influential
- Temperature, which should not exceed certain extremes; tolerance to heat is significant for some species
- Light, which provides energy to the ecosystem through photosynthesis
- Natural disasters can also be considered abiotic

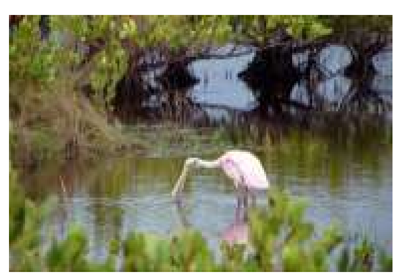
Biocenose (community) , is a group of populations of plants, animals, micro-organisms. Each population is the result of procreations between individuals of same species and cohabitation in a given place and for a given time. When a population consists of an insufficient number of individuals, that population is threatened with extinction; the extinction of a species can approach when all biocenoses composed of individuals of the species are in decline. In small populations, consanguinity (inbreeding) can result in reduced genetic diversity that can further weaken the biocenose.

Biotic (relations between organisms**) ecological factors** also influence biocenose viability; these factors are considered as either intraspecific (relations between organisms of the same species) and interspecific (relations between organisms of different species). Some common relations are cooperation, competition, mutualism, predation (eat or be eaten), parasitism, infectious diseases, and competing for limited resources (food, water, etc.).

The existing interactions between the various organisms are related to a permanent mixing of mineral and organic substances, absorbed by organisms for their growth, their maintenance and their reproduction, to be finally discarded as waste. These permanent recyclings of the elements (in particular carbon, oxygen and nitrogen) as well as the water are called biogeochemical cycles. They guarantee a durable stability of the biosphere (at least when human influence and extreme weather or geological phenomena are not taken in consideration). An ecosystem also tends to evolve to a state of ideal balance, reached after a succession of events).

Ecosystems are not isolated from each other, but are interrelated. For example, water may circulate between ecosystems by the means of a river or ocean current. These relationships between the ecosystems lead to the concept of a *biome*.

a **forest ecosystem**



a typical ecosystem

Ecology and Distinct Ecosystems - Biomes

Ecosystems and productivity - In an ecosystem, the connections between species are generally related to food and their role in the food chain. There are three categories of organisms in the food chain:

- **Producers** - usually plants which are capable of photosynthesis but could be other organisms such as bacteria around ocean which are capable of chemosynthesis.
- **Consumers** - animals, which are primary consumers (**herbivorous**), or secondary or tertiary consumers (carnivorous and omnivores).
- **Decomposers** - bacteria, mushrooms which degrade organic matter of all categories, and restore minerals to the environment. And decomposers can also decompose decaying animals

These type organisms form a relational sequence, in which each individual consumes the preceding one and is consumed by the one following, in what is called **food chain** or food network. In a food network, there will be fewer organisms at each level as one follows the links of the network up the chain.

These concepts associated with organisms in the food chain lead to the idea of **biomass** (the total living matter in a given place); considering **primary productivity** (the increase in the mass of plants during a given time) and **secondary productivity** (the living matter produced by consumers and the decomposers in a given time).

These two last ideas are key, since they make it possible to evaluate the load capacity -- the number of organisms which can be supported by a given ecosystem. In any food network, the energy contained in the level of the producers is not completely transferred to the consumers. And the higher one goes up the chain, the more energy and resources is lost and consumed. Thus, from an energy and environmental point of view, it is more efficient for humans to be primary consumers (to subsist from vegetables, grains, fruit, etc.) than as secondary consumers (from eating herbivores, omnivores, or their products, such as milk, chickens, cattle, sheep, etc.) and still more so than as a tertiary consumer (from consuming carnivores, omnivores, or their products, such as fur, pigs, snakes, alligators, etc.). An ecosystem(s) is unstable when the load capacity is overrun and is especially unstable when a population does not have an ecological balance but has over - consumers.

The study of productivity of ecosystems is sometimes estimated by **comparing three types of land-based ecosystems and the total of aquatic ecosystems:**

- The **forests** (1/3 of the Earth's land area) contain dense biomasses and are very productive. The total production of the world's forests corresponds to half of the primary production.
- **Savannas, meadows, and marshes** (1/3 of the Earth's land area) contain less dense biomasses, but are productive. These ecosystems represent the major part of what humans depend on for food.

Ecology and Distinct Ecosystems - Biomes

- **Extreme ecosystems** in the areas with more extreme climates -- deserts and semi-deserts, tundra, alpine meadows, and steppes -- (1/3 of the Earth's land area) have very sparse biomasses and low productivity
- Finally, **the marine and fresh water ecosystems** (3/4 of Earth's surface) contain very sparse biomasses (apart from the coastal zones).

Human activities over the last few centuries have seriously reduced the amount of the Earth covered by forests (**deforestation**), and have increased **agro-ecosystems** (agriculture). Moreover, in recent decades, an increase in the areas occupied by extreme ecosystems has occurred (desertification).

Ecological crisis - In general, an ecological crisis occurs with the loss of adaptive capacity when the challenge of an environment or of a species or a population evolves in a way unfavorable to coping with changes that interfere with that ecosystem, landscape or species survival; Examples: an increase of temperature, less significant rainfalls, overfishing, overpopulation. Ecological crises vary in length and severity, occurring within a few months or taking as long as a few million years. They may relate to one unique species or to many species. Also, an ecological crisis may be local such as an oil spill or global such as a rise in the sea level due to global warming. An ecological crisis can cause extinction of a species or it may simply reduce the quality of life of the species being impacted.

Biomes

A **biome** is a homogeneous ecological formation that exists over a large region. More specifically, a **biome** is a climatic and geographically defined area of ecologically similar communities of plants, animals, and soil organisms. Biomes are defined based on factors such as plant structures (such as trees, shrubs, and grasses), leaf types (such as broadleaf and needleleaf), plant spacing (forest, woodland, savanna), and other factors like climate; biomes are not defined by genetic, taxonomic, or historical similarities. Biomes are often identified with particular patterns of environmental features. **Biomes are unique situations. They are very specialized ecosystems that only exist in certain parts of the world.** They are ecosystems that are defined by their environments. Factors like temperature, rainfall, and altitude all decide what type of life a biome can support. Let us consider a few specific biomes.

Tropical rain forests are warm and humid. Standing on the ground, one can look up and see a huge canopy of leaves. The trees are very tall, some fifty feet high. Even though the Sun is shining, one is walking around in the shade. As one walks through this biome, one sees lots of different living creatures. There are lots of birds, some tiny mammals, but most of all insects. There are bugs everywhere. They crawl, fly, and jump all around. As one continues walking, one notices all of the dead leaves on the ground. Every now and then a leaf falls from above and adds to the pile.

Ecology and Distinct Ecosystems - Biomes

A desert is hot and dry. It's not just hot; it is incredibly hot and dry. . One's lips are chapped and one becomes very thirsty. The ground is all cracked and it may have been over a year since it rained. One sees cacti (if it is one it is a cactus) and a bird every now and then. There are no trees at all. There are a few dried up bushes and a few insects on the ground. After the Sun goes down one can see different animals coming out of the ground. When it cools off at night, the burrowing animals come out to hunt the bugs. During the day it is to hot for them to come out on the surface..

The **tundra** is a very cold region. Life is just as challenging in the tundra as it is in the desert. You usually find tundra biomes the north pole or south pole. If one came in the winter, it would be dark all of the time. In the summer, the Sun barely sets. Even with all the light there is still very little life. One sees lot of lichen and mosses on the rocks, one can even see the rocks under the snow. There are no trees. It would not matter anyway; the roots could not go deep because the soil is frozen.

The Sahara Desert, one of the hottest places on Earth

Part II: Life Science

Lesson 1: Biology: The Study of Living Things

Do You Know?

Everything in the world is either a living thing or a non-living thing. Sometimes it can be difficult to determine a living thing from a non-living thing. To be able to tell the difference you must know the characteristics and functions of living things. A living thing is also called an organism. From observation, study and research we have learned a lot of facts about living things. We know what attributes many living things have in common; we know what attributes that cause many living things to be different. We know how to describe most living things. We know how long most living things usually live. We know what causes many living things to die. We know the kind of environment in which most living things strive and survive. We know how most living things reproduce their own kind. We know how most living things are alike. We know how most living things differ. We know…..

However, there are many things that we do not know or understand about living things. And yet every day we learn more about livings things that we did not know in the past. Prior to the 20th century, most biologists considered all living things to be classifiable as either a plant or an animal. But in the 1950s and 1960s, most biologists came to the realization that this system failed to accommodate the fungi, protists, and bacteria. By the 1970s, a system of **Five (5) Kingdoms** had come to be accepted as the model by which all living things could be classified. At a more fundamental level, a distinction was made between the **prokaryotic** the kingdom of bacteria and the four **eukaryotic** kingdoms (plants, animals, fungi, and protists). The distinction recognizes the common traits that eukaryotic organisms' cells share, such things as nuclei, cytoskeletons, and internal membranes, whereas prokaryotic organisms' cells have no organized nuclei or membrane.

The scientific community was understandably shocked in the late 1970s by the discovery of an entirely new group of organisms -- the Archaea. Dr. Carl Woese and his colleagues at the University of Illinois were studying relationships among the prokaryotes using DNA sequences, and found that there were two distinctly different groups. Those "bacteria" (now archaeans) that lived at high temperatures or produced methane clustered together as a group differed well away from the usual bacteria and the eukaryotes. Because of this vast difference in genetic and biochemical makeup, it was proposed that organisms be divided into **two domains: Prokaryotes** (Bacteria and Archaeans) and **Eukaryotes** (Animals, Plants, Fungi, and Protists). Although it is true that most archaeans do look like bacteria under the microscope, they are biochemically and genetically different from bacteria as they are from some eukaryotes. The domain concept has been accepted to a large degree. However, most biologists still only classify organisms in **five (5) different kingdoms.**

Biology: The Study of Living Things

Characteristics of Living Things

What do an elephant, a butterfly, a baobab tree and a cactus plant have in common? This is not a great riddle of mystery. They answer is easy. All four are living things. The study of living things (animals, plants, and other living things) is called **life science**. Another name for life science is **biology**. Plants, human beings and other animals are all organisms. An organism is a living thing that performs five (5) basic life functions or activities. Organisms come in all shapes and sizes. Tiny flies, tomato plants, fish, goats, lions, human beings baobab trees are all organisms. Organisms live in the water, above ground, below ground, in trees and elsewhere.

What are the five (5) basic functions that all organisms or living things perform?

1. **Composition**: All living things are made of building blocks called cells

2. **Energy - Food**: All Living things use energy;
   (They get energy by eating or making food)

3. **Growth and Development**: All Living things grow and develop
   (Change over time)

4. **Reproduction**: All Living things produce or make more of their own kind
   (Offspring)

5. **Adaptation**: All Living things respond to their environment.

6. **Waste - Excretion**: All living things produce and dispose of waste.
   (Excess gas, liquid or solid)

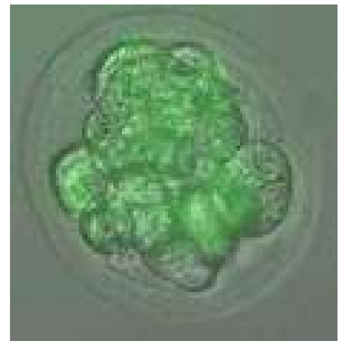
Monarch Butterfly

Baobab Tree

Biology: The Study of Living Things

All Living Things Are Made of Cells

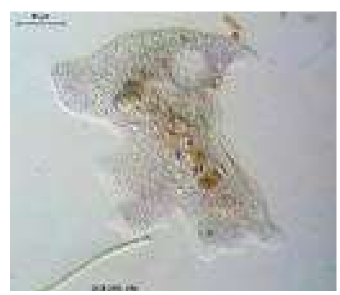
All organisms (living things) are made of cells. A "cell" is the smallest living part of an organism. Some organisms such as Algae and Euglena (plantlike) and Amoeba and Paramecium (animal like) are made of only one cell. That single cell is the entire organism. Many other kinds of organisms, including animals, plants and human beings are made of billions of cells. Organisms with many cells, for example, animals, have different kinds of cells: bone cells, nerve cells, muscle cells and blood cells. Plants have leaf cells and root cells. Each kind of cell in an organism performs a different function. For example, nerve cells carry messages to and from the brain. Muscle cells make parts of the body move. Blood cells carry oxygen to all other cells. A plant's leaf cells make food for the plant.



An Animal Cell

Although all living things are made of cells; not all cells are alike. Plant cells have a boxlike shape. Some plant cells even contain a green material called "chlorophyll." When sunlight strikes chlorophyll, the cell can make food for the plant. Animal cells do not contain chlorophyll, and animal cells are not shaped like a box. The basic difference between most plant and animal cells include their covering, color, and shape. Cells also differ depending on the types of jobs they do and the parts of the organism where they are contained.

A Plant Cell



An Amoeba

Classifying Living Things;

The Highest Level of Classification: Kingdom

There exist millions, billions, even trillions of living things on earth today. Many are alike and many are different. To help scientists to study and learn more about organisms (living things), organisms are classified into groups. First they are organized and listed in large groups; then these larger groups are further organized in to smaller sub-groups. The smaller the group, the more similar are the organisms in that group are to each other. The larger group into which all living things are classified is called a "kingdom."

Biology: The Study of Living Things

Organisms are organized and distinguished on the basis of how their cells are organized and their methods of nutrition. Foods are important factors used to classify organisms into kingdoms. Each organism belongs to only one (1) kingdom. Each kingdom contains organisms that are not listed in any other kingdom. All organisms belong to one of the six (6) kingdoms.

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Kingdom	Types of organisms
Bacteria*	bacteria, blue-green algae, and spirochetes; **archaeans**
Protists	protozoans and algae or various types
Fungi	funguses, molds, mushrooms, yeasts, mildews, and smuts
Plants	mosses, ferns, woody and non-woody flowering plants
Animals	sponges, worms, insects, fish, amphibians, reptiles, birds and mammals

*Some biologists divide bacteria and archaeans as two different kingdoms, making the number of kingdoms six (6).

The Animal Kingdom

All animals share certain common characteristics. These characteristics distinguish them from organisms in other kingdoms.

- **Energy**

Animals cannot make their own food. All animals get their food from other organisms.

- **Movement**

Animals can move from place to place, at least at some time during their lives.

- **Composition**

Animals are made of many cells; animals' bodies have different kinds of cells; each kind of cell has a different function.

- **Cell Covering**

Animal cells do not have a cell wall. Their cells' outer covering is a flexible membrane.

- **Oxygen-Carbon Dioxide**

Animals take in oxygen and give off carbon dioxide.

- **Reproduction**

Some animals reproduce by laying eggs. Other animals reproduce by giving birth to live young animal.

- **Habitat**

Animals live on land or in water or both.

Fish

Lions

African Family

Biology: The Study of Living Things

The Plant Kingdom

You might think that grass, trees, and moss do not have much in common. But they do because they are all members of the plant kingdom. All plants share the following characteristics.

- **Energy**

All plants make their own food. They do this through a process called **photosynthesis**. In photosynthesis, plants use the energy in sunlight to change water and carbon dioxide into a kind of sugar called *glucose*. Glucose is food for the plant.

- **Movement**

Plants do not move from place to place.

- **Cell Composition**

All plants are made of many cells; a plant has different kinds of cells; each kind of cell has a different function.

- **Cell covering**

A plant cell has a rigid outer covering called the cell wall.

- **Carbon Dioxide-Oxygen**

Plants take in carbon dioxide and give off oxygen.

- **Reproduction**

Most kinds of plants reproduce with seeds; the seeds develop in flowers or cones; ferns and mosses reproduce with spores.

- **Habitat**

Plants live on land.

Tea Plant

Acacia Plant

Palm Trees

Biology: The Study of Living Things

The Fungus Kingdom

If you leave a piece of fruit out in the air too long, a fuzzy green or black material will grow on it. The material is mold. Mold is a member of the fungus kingdom. Other members of the fungus kingdom include yeast, mushrooms, and puffballs. Although these organisms do not look alike, all fungi have the following characteristics in common.

- **Energy**

Fungi cannot make their own food; most fungi feed on dead plants and animals or the waste of plants and animals.

- **Movement**

Fungi cannot move from place to place

- **Cell Composition**

Some fungi are made of a single cell; other fungi are made of many cells.

- **Cell covering**

Like plant cells, fungi cells have a cell wall; however, fungi cell walls and plant cell walls are made of different materials.

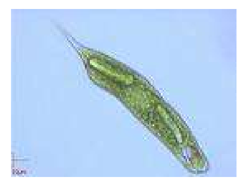
- **Reproduction**

Fungi reproduce with spores.

- **Habitat**

Fungi live on land.

Coral Fungus



Euglena, Protist

The Protist Kingdom

If you have a fish tank, you know you have to keep it free of algae. Algae can cloud the water and coat the rocks with green slime. Algae belong to the protest kingdom. Some algae, such as seaweed, are made of many cells strung together in ribbons. Most members of the protest kingdom are one-celled organisms. They are so tiny that you can see then only with a microscope. All protist have the following characteristics in common.

- **Energy**

Algae and some other protists can make their own food by carrying out photosynthesis; other protists, such as the amoeba, cannot make their own food; they get food from other organisms.

- **Movement**

Some protists can move from place to place; for example, Euglena moves by whipping its tail back and forth; other protists cannot move from place to place.

- **Cell Composition**

Some algae are made of many cells. Other algae and most other protists are made of only one cell.

- **Habitat**

Most protists live in water; some can live on land.

Biology: The Study of Living Things

The Bacteria Kingdom

If you have a sore throat and it hurts to swallow, you might have an infection called "strep throat." Strep throat is caused by a kind of bacteria. Other kinds of bacteria can cause diseases. However, bacteria are harmless to humans. Some bacteria are helpful. Bacteria that live in your intestines help you to digest food. Some of those bacteria make vitamins you need. People use bacteria to make yogurt, cheeses, sauerkraut, and other products. Bacteria that live in soil breakdown dead plants, animals, and wastes into simple substances that plants can use. Some bacteria can decompose oil and are used to help clean up oil spills. All bacteria have the following common characteristics.

- **<u>Cell Composition</u>**

All bacteria are made of only one cell.

- **<u>Cell Nucleus</u>**

Bacteria cells do not have a nucleus.

- **<u>Cell Covering</u>**

Bacteria cells have a cell wall.

- **<u>Energy</u>**

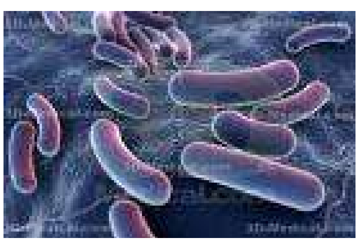
Some bacteria make their own food; however, most bacteria feed on other organisms.

- **<u>Oxygen</u>**

Most bacteria need oxygen to survive; some bacteria cannot live where there is oxygen.

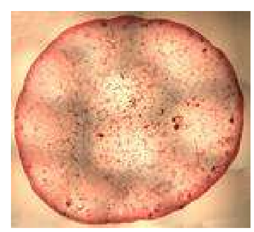
- **<u>Classification</u>**

Bacteria are classified into three groups according to their shape: round, spiral, and rod.



Bacteria – rod

Bacteria – spiral



Coccu Bacteria - round

- Rod shape bacteria cause food poisoning.
- Spiral shape bacteria are used in making cheese.
- Round shaped bacteria causes infections in human beings.

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Archaeans are classified by most biologists in the bacteria kingdom because they look like bacteria under the microscope. However, they are genetically (DNA) and biochemically very different from bacteria. Thus, some biologists classify them in a separate kingdom by themselves.

Biology: The Study of Living Things

Activity 1

1. What is an organism?

2. What is a cell?

3. What are the six (6) characteristics that all living things exhibit?

4. What are two names we use to describe the study of living things?

5. What is the name that we use to classify living things in five (5) large distinct groups?

6. Name one or two characteristics that distinguish **animals** from members of other kingdoms.

7. Name one or two characteristics that distinguish **plants** from members of other kingdoms.

8. Name one or two characteristics that distinguish **fungi** from members of other kingdoms.

9. Name one or two characteristics that distinguish **protists** from members of other kingdoms

10. Name one or two characteristics that distinguish **bacteria** from members of other kingdoms.

11. Name a specific **animal**; draw a picture of the **animal**; describe the animal to the class; and discuss how the **animal** exhibits some of its basic life functions.

12. Name a specific **plant**; draw a picture of the **plant**; describe the **plant** to the class; and discuss how the **plant** exhibits some of its basic life functions.

13. Name a specific **fungus**; draw a picture of the **fungi**; describe the **fungi** to the class; and discuss how the **fungi** exhibits some of its basic life functions.

14. Name a specific **protist**; draw a picture of the **protist**; describe the **protist** to the class; and discuss how the **protist** exhibits some of its basic life functions.

15. Name specific bacteria; draw a picture of the **bacteria**; describe the **bacteria** to the class; and discuss how the **bacteria** exhibits some of its basic life functions.

Part II: Life Science

Lesson 2: The Five (5) Major Life Processes of Living Things

Do You Know?

We know that all objects or entities that exist are either living things or non-living things. However, it is important to be able to determine what a living thing is and what it is not. For example some living things, like a poisonous stonefish, may appear to be a non-living thing. Just stepping on a poisonous stonefish can cause a lot of pain. It can even be fatal (i.e. it can cause one to die).

In a rain forest, one encounters many interesting objects and entities. Also, many different plants and animals that live in a rain forest are not commonly seen in other places. If one is not sure that a given object or entity is a living thing or a non-living thing, how can one make a scientific determination? One knows that all living things are made of building blocks called cells. But one can not see a cell or cells with the naked eye. One would need to take the object or entity apart or place it under a microscope to determine whether or not it is made of cells. To do this is not feasible, practical or wise. However, there are five (5) other characteristics of all living things. It is often possible to observe one or more of these characteristics with the naked eye and make a determination whether or not the object or entity is alive (a living thing). The other five (5) characteristics of living things are what we call the five (5) basic life processes of all living things. We study these processes in this lesson.

The Five (5) Basic Life Processes of All Living Things

The Five (5) Basic Life processes of All Living Things

The five (5) functions of all living things are the same as the six (6) characteristics of living things, excluding the characteristics that all living things are composed of building blocks called cells. The five (5) functions (processes) of all living things are:

Functions (Processes)	**Brief Description**
Energy – Food	Getting and using food
Growth and Development	It grows and changes during its life cycle
Reproduction	Making of organisms of the same kind
Adaptations	Respond or react to the environment
Waste – Excretion	Produce and dispose of excess liquids or solid materials

A. Energy - Food

All organisms carry out basic life processes which include growth and development, making more organisms of the same kind, responding and reacting to the environment, producing and disposing of waste, and others. All life processes require **energy** (the ability to do work). Organisms get energy by getting and using food. Some organisms produce their own food, like all plants. Some organisms depend on other organisms for their food, like all animals do. Plants get energy from the sun (sunlight). Animals get energy from nutrients in the food they eat.

B. Growth and Development; C. Reproduction

The Cycle of Life: Birth, Growth and Change, Reproduction, and Death

A **life cycle** is all the stages in an organism's life. During the typical life of an organism, it goes through these stages:

- **Birth**: The organism's life begins
- **Growth and Development**: The organism usually gets larger; it may take on new forms
- **Reproduction**: The organism creates new organisms like itself **(offspring**)
- **Death**: The organism's life ends

The **life cycle** of a **monarch butterfly** exhibits some of the more distinguishable growth and change of any organism. In the life cycle of this organism, one can also discuss the life function of reproduction. We present the four (4) stages of the life cycle of this organism; it includes a discussion of reproduction for this particular organism.

The Five (5) Basic Life Processes of All Living Things

Egg

Stage 1: Egg
The female lays eggs on a leaf.
Each egg grows until it is ready to hatch.

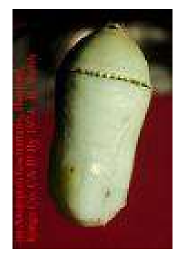
Stage 2: Caterpillar
After about one (1) week, a caterpillar hatches from the egg.
The caterpillar eats often; it is storing food energy for the next stage of its life cycle.

Caterpillar

Stage 3: Pupa
The caterpillar stops eating.
It forms a hard case around itself called a **pupa**.
Inside the pupa, the caterpillar goes through many changes.

Stage 4: Adult
After about a week, the adult butterfly comes out of the pupa.
Its body is now completely different.
A female butterfly will lay eggs to start a new life cycle.

Butterfly



Pupa

D. Adaptation

Adaptation is a characteristic that helps an organism respond and react to its environment. In particular, adaptations help protect living things. Adaptations help organisms to survive in different ways. Perhaps, the most important adaptations are for protection. Organisms need protection from the weather and from their predators.

The shell of a turtle is an example of an adaptation that protects a living thing. When a turtle needs protection, it curls up inside of its shell. Rabbits sometime use their speed to run to safety if a predator comes close. Many organisms use camouflage for protection. Camouflage is an adaptation that allows an organism to blend in with its environment. White rabbits blend in with snow. Brown rabbits match their forest habitat.

Most living things have a variety of adaptations to help them survive. The wool of a lamb provides the lamb with a warm coat that helps the lamb survive cold winters. The long neck of a giraffe helps the giraffe to find food in high places where most other organisms cannot reach. Frogs have long sticky tongues to help them to catch insects for food energy. The coloring of a flower is an adaptation that attracts insects to help the flower reproduce. The Indian butterfly uses camouflage to protect itself. With its wings folded, it looks like a dead leaf; thus predators do not easily locate it while resting.

The Five (5) Major Life Processes of Living Things

E. Waste - Excretion

All organisms create and dispose waste during the process of **catabolism**. **Metabolism** is the complete set of chemical reactions that occur in living cells. These processes are the basis of life, allowing cells to grow and reproduce, maintain their structures, and respond to their environments. Metabolism is usually divided into two categories. **Catabolism** yields energy, an example being the breakdown of food in cells. **Anabolism**, on the other hand, uses this energy to construct components of cells such as proteins and nucleic acids

Waste for a given organism may be in the form of a gas, a liquid or a solid, or all three. For example, for certain organisms, blood carries waste to the lungs where waste gases are disposed by breathing. For mammals, carbon dioxide is disposed from the organism by breathing. For many organisms, liquid waste, created when cells break down certain chemicals, is disposed in different ways. In thin-layered animals such as sponges, liquid and solid wastes are simply washed away. Flatworms and earth worms have tubules into which wastes drain and are passed from the organisms. Reptiles live in dry places; their kidneys turn liquid waste into a dry paste. Birds do not store liquid wastes in a bladder; instead they turn their liquid waste into a paste that is eliminated from the body with the solid waste.

Excretion is the process of eliminating waste products of metabolism and other non-useful materials. It is an essential process performed by all organisms. In one cell organisms, waste products are disposed directly through the surface of the cell. Many-cell organisms have more complex methods of excretion. Larger plants eliminate gases through the stomata, or pores, on the surface of leaves. Many animals have special organs for excretion. In humans, the main organs for providing excretion are the kidneys and urinary organs, for disposing urine or liquid waste and the large intestines for eliminating solid waste. The skin and lungs also perform an excretion function. The skin eliminates water and salts by perspiration and the lungs dispose water vapor and carbon dioxide through breathing.

Some plants have been observed to translocate waste into leaves and then the leaves were shed; thus the leaves were also serving as the plant's organ of excretion. Aquatic animals usually excrete ammonia directly into the external environment, being very soluble the water readily dilutes it. For animals living on land, ammonia-like compounds are converted into other nitrogenous materials; ammonia itself is toxic.

For mammals, there are three (3) major excretory processes: the formation of liquid waste in the kidney and the formation of carbon dioxide, which is then exhaled from the lungs. Solid waste is formed in the large intestines, and then released through the anus.

The Five (5) Basic Life Processes of All Living Things

Activity 1

1. What are the five (5) basic functions of an organism?
2. What is a energy?
3. Define and discuss the concept of camouflage?
4. What are the two fundamental ways that living things get food?
5. What is an organism's life cycle?
6. Define and discuss the concept of metabolism?
7. Define and discuss the concepts of growth and development?
8. Define and discuss the concept of reproduction?
9. Define and discuss the concept of adaptation?
10. Define and discuss the concept of waste (metabolic waste)?
11. Define and discuss the concept of excretion?
12. Discuss the process of adaptation for two or more organisms.
13. What is the different between catabolism and anabolism?
14. Discuss why organisms need food.
15. Discuss in details the life cycle of a monarch butterfly.

Part II: Life Science

Lesson 3: Cells, Tissues, Organs, and Organ Systems

Do You Know?

Organisms that are more complex have many different parts. An organism's body part that performs a certain activity or function for that organism is called a structure. In complex organisms, small body parts are grouped together to form larger parts. These larger parts are grouped together to form systems. An organism's parts and systems work together to permit the organism to perform the basic life processes and to survive grow and do other things.

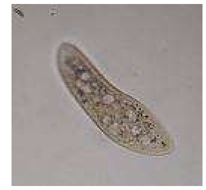
A system is a group of organs that work together and provide the organisms with the opportunities and advantages to survive and thrive in their environment. A system is the most complex organization of body parts is an organism. A system is the highest level of progression of a complex organizational of life sustaining parts of an organism beginning from cells to tissues to organs to systems.

In this lesson, we study the composition and functions of cells, tissues, organs, and systems. An organism needs all of its systems to survive. However, the nervous system (for organisms who have them) is the most important system. This system transfers messages to all other systems, directing them to perform their activities and functions.

Cells, Tissues, Organs, and Organ Systems

A. Cells

All organisms are made of cells. A **cell** is the smallest living part of an organism. Some kinds of organisms, such as bacteria, are made of only one cell. That single cell is the organism's entire body. Many other kinds of organisms, including elephants, trees, and people, are made of trillions of cells.

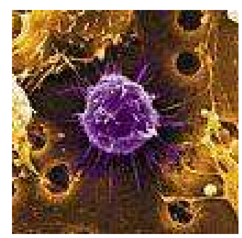


Paramecium

The body of a many-called organism is made of different kinds of cells. For example, many animals have bone cells, nerve cells, muscle cells, and blood cells. Plants have leaf cells and root cells.

Anthrax bacterium

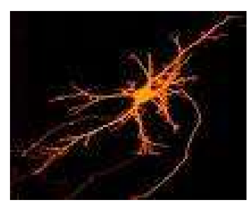
Each kind of cell in an organism performs a different function. For example, nerve cells carry messages to and from your brain. Muscles cells make parts of your body move. Blood cells carry oxygen to all your other cells.
A plant's leaf cells make food for the plant.



Human bone marrow cell

Plant root cells

Plant leaf cells



Human nerve cell

Cells, Tissues, Organs, and Organ Systems

B. Animal Cell

All animals, including humans, are made of different kinds of cells. This drawing shows a typical animal cell and the structures inside it. Each structure carries out a different function in the cell.

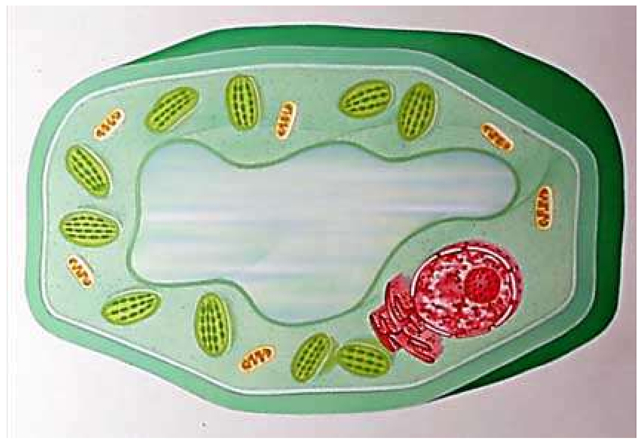
Model of an Animal Cell

- **Cell Membrane** – A soft, flexible **cell membrane** surrounds the cell. It controls the movement of substances into and our of the cell. Water and other materials enter the cell, and wastes leave the cell.
- **Cytoplasm** – **Cytoplasm** is a jellylike "soup" that fills most of the cell. Other cell structures float in the cytoplasm.
- **Nucleus** – The **nucleus** controls everything that the cell does. The nucleus "tells" the other cell structures how and when to carry out their functions. It also controls how and when the cell divides to make new cells.
- **Vacuoles – Vacuoles** are storage spaces in the cell. They store water and nutrients until other cell structures need them. Some vacuoles store wastes until the cell can get rid of them.
- **Mitochondria** – **Mitochondria** are the "powerhouses" of the cell. They combine oxygen with the nutrients in food. This releases energy. The cell uses the energy to carry out all its activities.

Cells, Tissues, Organs, and Organ Systems

C. Plant Cell

All plants are made of different kinds of cells. This drawing shows a typical plant cell and the structures inside it. Plant cells have the same structures as animal cells. But plant cells also have two other structures. They are chloroplasts and a cell wall. Animal cells do not have those structures.



A Model of a Plant Cell

- **Cell Wall**

A rigid **cell wall** is the outer covering of a plant cell. It is made of a stiff material that gives plant cells a boxy shape.

- **Chloroplasts**

Chloroplasts (KLOR uh plasts) make food for the plant. They hold a green substance called **chlorophyll** (KLOR uh fil). Chlorophyll captures the energy in sunlight. Chloroplasts use this energy to combine carbon dioxide and water. This produces a kind of sugar called **glucose** (GLOO kohs). Glucose is the plant's food.

- **Cell Membrane**

It controls the movement of substances into and out of the cell. It controls the movement of substances into and out of the cell. Water and other materials enter the cell, and wastes leave the cell.

- **Cytoplasm**

Cytoplasm (SY tuh plaz um) is a jellylike "soup" that fills most of the cell. Other cell structures float in a cytoplasm.

- **Nucleus**

The **nucleus** (NOO klee us) controls everything that the cell does. The nucleus "tells" the other cell structures how and when to carry out their functions. It also controls how and when the cell divides to make new cells.

Cells, Tissues, Organs, and Organ Systems

- **Vacuoles**

Vacuoles are storage spaces in the cell. They store water and nutrients until other cell structures need them. Some vacuoles store wastes until the cell can get rid of them.

- **Mitochondria**

Mitochondria (my tuh KAHN dree uh) are the "powerhouses" of the cell. They combine oxygen with glucose. This releases energy. The cell uses the energy to carry out all its activities.

D. Tissues

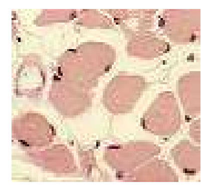
A tissue (TISH oo) is a group of cells that work together to perform a certain function. In animals, for example, muscle cells are grouped together to form muscle tissue. In plants, certain cells are grouped together to form bark tissue. Different kinds of tissue perform different functions.

Animal Tissues

The bodies of most animals are made of different kinds of tissues. Here are some examples.

- **Muscle Tissue**

  Muscle tissue is made of many muscle cells. Muscle cells can **contract,** or get shorter. When all the cells contract at the same time, the whole tissue becomes shorter. When the cells relax, the whole tissue becomes longer again.



Muscle Tissue

- **Bone Tissue**

  Bone tissue forms the bones in an animal's skeleton. The skeleton gives the animal its shape. When muscles pull on bones, the bones move.

Bone Tissue

- **Blood**

  Blood is a tissue. It contains blood cells floating in a liquid. Some blood cells carry oxygen to all parts of your body. Other blood cells fight germs that cause disease. The liquid part of your blood carries water and other materials to all the cells in your body. The liquid part also carries wastes away from your body cells.

Blood Cells

Cells, Tissues, Organs, and Organ Systems

E. Plant Tissues

Plants have different kinds of tissues. Here are some examples.

Bark

- Bark

  The outside of a tree or other woody plant is covered with bark. Bark helps keep water inside the plant. Bark also protects the plant against insects and diseases.

Tubes - plants

- Tubes

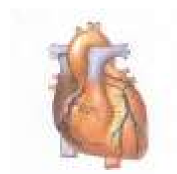
  Some plant cells are grouped together to form tubes. One kind of tube carries water from the plant's roots to the leaves. Another kind of tube carries food from the leaves to the other parts of the plant.

F. Organs

Different kinds of tissues are grouped together to form an organ. Each organ performs a different function.

- Animal Organs

  Simple animals, such as earthworms and insects, have only a few simple organs. Complex animals have more kinds of organs. Here are some examples of organs that people, horses, cows, and other complex animals have.



Heart

- Heart

  Your heart is made mostly of muscle tissue and nerve tissue. These tissues work together to pump blood throughout your body.

- Lungs

  Lungs contain tissue that form a kind of bag, tubes, tiny sacs, and blood vessels. These tissues work together to take in oxygen from the air you breathe. They also release waste gases into the air.

Stomach

- Stomach

  Tissues in the lining of the stomach produce chemicals that break food down. Muscle tissue in the stomach contracts and relaxes to mix the chemicals with the food.

- Plant Organs

  Like animal organs, plant organs are made of different kinds of tissues. You are probably most familiar with plants that have roots, stems, and leaves. Roots, stems, and leaves are plant organs. Simple plants, such as mosses, do not have these plant organs.

- Leaves
  The main function of these organs is to make food for the plant. Leaves also have tissues that give them their shape. Some leaf tissue forms a waxy material that coats the leaves. The waxy coat keeps leaves from losing water and drying up.

Leaves

- Stems
  Firm tissues in these organs hold the leaves up to the sunlight. Some tissues help move water and other materials from the roots to the leaves. Other tissues move food from the leaves to other parts of the plant.

Stem

- Roots
  Roots are organs that carry out three functions for a plant. They take in water and other materials from the soil. They hold the plant in the soil. And they store extra food that the plant doesn't need right away. A different kind of tissue performs each function.

Roots

G. Organ Systems
Different organs work together to form an **organ system**. Different systems carry out different functions. For example, a plant's roots, stems, and leaves work together to make, transport, and store food for the plant.

H. Animal Systems
Different animals have different kinds of organ systems. Two systems in complex animals are the digestive (dy JES tiv) system and the circulatory (SUR kyuh luh to ee) system.

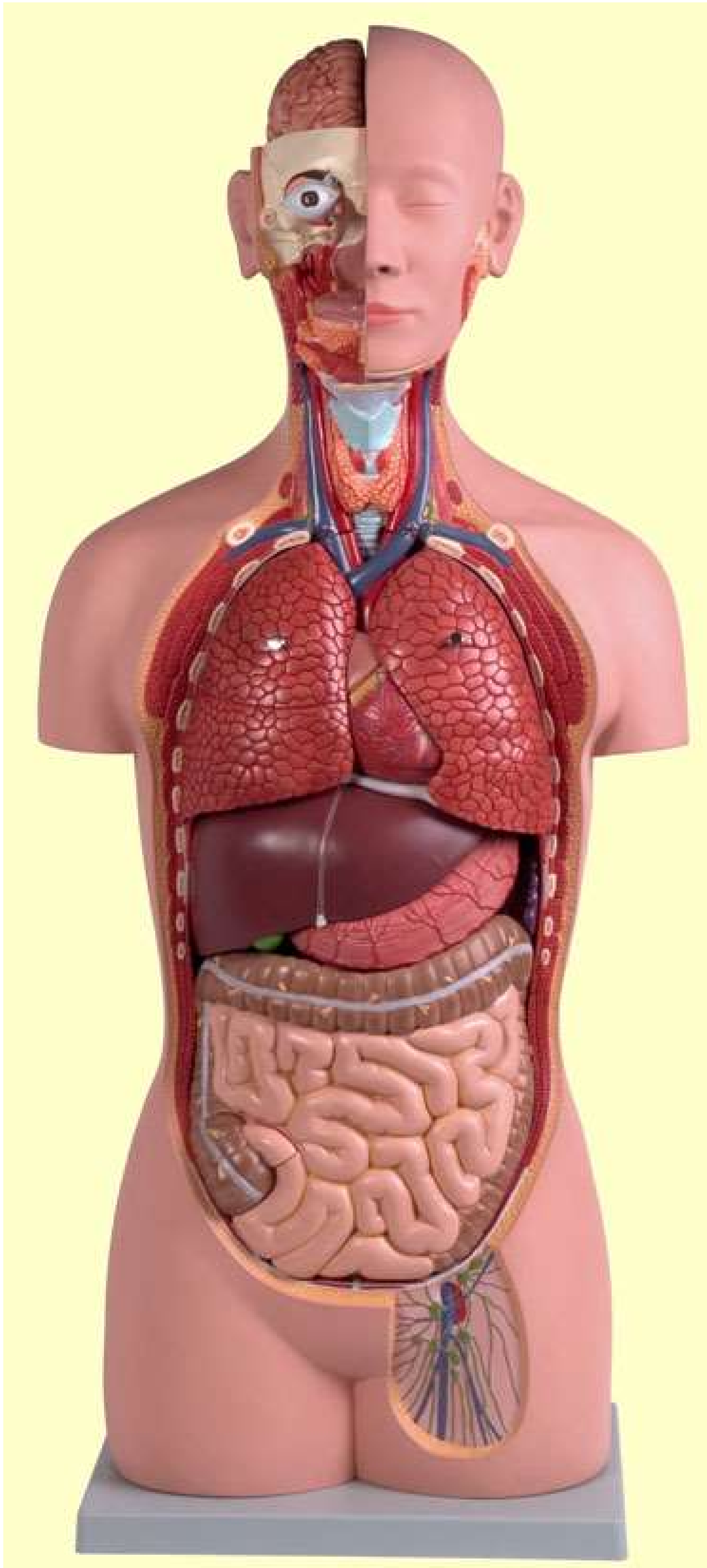
Digestive System
The digestive system breaks food down into simple materials that the animal's body can use. The main organs in this system are the mouth, stomach, small intestine, large intestine, liver, and pancreas.

Circulatory System
The circulatory system moves blood throughout the animal's body. The organs in this system are the heart and blood vessels. The heart pumps blood through the blood vessels.

Cells, Tissues, Organs, and Organ Systems

Systems Work Together

All the systems in an animal's body work together to keep the animal alive and healthy.



Cells, Tissues, Organs, and Organ Systems

What is Metabolism?

Metabolism is such a big word to explain a simple idea. We all need energy to survive. Plants, animals, or bacteria, we all need energy. Energy doesn't just float around in a or we can use to survive. We need to eat (mainly sugars) and digest food. That process of chemical digestion and its related reactions is called metabolism. Metabolism is the total of all of the chemical reactions an organism needs to survive.

Two main chemical processes make our world go round. There are two simple chemical reactions. The first is called glycolysis. That is the breakdown of sugars. The second process is called photosynthesis. That is the reaction that builds sugars. You need to remember that the overall metabolism of an organism includes thousands of chemical reactions. Glycolysis and photosynthesis are the cornerstones to life.

Building Up

First, you need to build up the molecules that store energy. We'll start with photosynthesis. It's no use explaining the breakdown of sugars without telling you how they were made.

$$\text{LIGHT (Energy)} + CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$$

GLUCOSE (C6H12O6)
OXYGEN GAS
↓
CARBON DIOXIDE
WATER
ENERGY

This is the reaction that only plants can do (and some algae/bacteria). They take sunlight and combine carbon dioxide (CO_2) and water (H2O). They create glucose ($C_6H_{12}O_6$) and oxygen gas (O_2). Remember, plants put the energy in glucose.

Breaking Down

It is metabolism and the process of glycolysis that makes that energy out of the sugar related molecules.

$$C6H12O6 + O2 \rightarrow \text{Usable Energy (ATP)} + CO2 + H2O$$

Cells then use that extra energy to power the functions of the cell. The energy is not still floating around; it is stored in an excitable compound called adenosine.

Cells, Tissues, Organs, and Organ Systems

Activity 1

1. What is an organism?

2. What is a cell?

3. What are the six (6) characteristics that all living things exhibit?

4. What are two names we use to describe the study of living things?

5. What is the name that we use to classify living things in five (5) large distinct groups?

6. Name one or two characteristics that distinguish **animals** from members of other kingdoms.

7. Name one or two characteristics that distinguish **plants** from members of other kingdoms..

8. Name one or two characteristics that distinguish **fungi** from members of other kingdoms.

9. Name one or two characteristics that distinguish **protists** from members of other kingdoms

10. Name one or two characteristics that distinguish **bacteria** from members of other kingdoms.

11. Name a specific **animal**; draw a picture of the **animal**; describe the animal to the class; and discuss how the **animal** exhibits some of its basic life functions.

12. Name a specific **plant**; draw a picture of the **plant**; describe the **plant** to the class; and discuss how the **plant** exhibits some of its basic life functions.

13. Name a specific **fungus**; draw a picture of the **fungi**; describe the **fungi** to the class; and discuss how the **fungi** exhibits some of its basic life functions.

14. Name a specific **protist**; draw a picture of the **protist**; describe the **protist** to the class; and discuss how the **protist** exhibits some of its basic life functions.

15. Name a specific **bacteria**; draw a picture of the **bacteria**; describe the **bacteria**

Part II: Life Science

Lesson 4: The Human Organ Systems

Do You Know?

Humans and other primates are made of trillions of cell. They are the most complex of all animals and all life form. As stated in another lesson, cells are grouped together to form tissues. Tissues form organs. And organs form organ systems. The Human Organ Systems work together to keep humans alive and healthy. There are many things that one could learn and perhaps should learn about biology. However, most scientists/teachers agree that to understand the composition of the human body, how it functions and how to keep it healthy is one of the greatest lessons that everyone should learn in biology. In this lesson the reader will learn these and more things about the biological and genetic composition of humans.

The following table describes what each system does. It also identifies the main organs in each system.

Human Organ System

System	Main Organs	Functions
Skeletal system	Bones	• Supports your body and gives it shape • Protects your internal organs • Helps you move • Stores substances • Makes blood cells
Muscular system	Muscles	• Moves your body parts • Moves food through your digestive system • Pumps blood through your circulatory system • Makes you breathe
Digestive system	Mouth, esophagus, stomach, small intestine, liver, gall bladder, pancreas, large intestine, rectgum, anus	• Breaks down food into simple substances that your cells can use • Gets rid of solid wastes from digestion
Excretory system	Kidneys, ureters, bladder, urethra, skin, lungs	• Removes liquid wastes and waste gases
Respiratory system	Mouth, nose, trachea, bronchi, lungs	• Takes in oxygen from the air you breathe • Gets rid of waste gases (carbon dioxide and water vapor)
Circulatory system	Heart, arteries, veins, capillaries	• Moves blood throughout your body • Delivers nutrients and oxygen to all cells • Removes carbon dioxide and wastes from cells • Helps fight disease
Nervous system organs	Brain, spinal cord, nerves, sense organs	• Controls all other systems in your body • Receives information about your environment • Stores memories • Allows you to think

Human Organ System

I. Skeletal System
J.

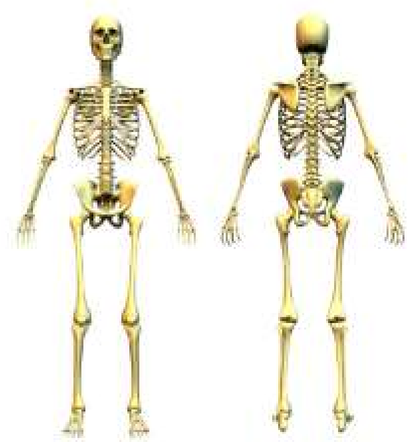
Your body has two organ systems that work together to help you move. They are the skeletal system and the muscular system. The **skeletal system** is made of bones and cartilage. **Cartilage** (KAR ti lij) is a strong tissue that is more flexible than bone. Bones and cartilage make up the framework of your body

Functions of the Skeletal System

Your skeletal system performs five important functions.

- It supports your body and gives it its shape.
- It protects your internal organs. For example, your skull protects your brain.
- It allows you to move when muscles pull on bones.
- It stores substances such as calcium.
- It makes red blood cells that carry oxygen and white blood cells that fight germs.

The Skeletal System



Types of Joints

Two or more bones meet at a joint. Different kinds of joints allow different kinds of movement. For example, your shoulder joint lets you move your arm in a large circle. Your elbow joint lets you move your lower arm toward and away from your upper arm.

The bones of some joints are not moveable. For example, the bones that make up your skull are joined tightly together and do not move.

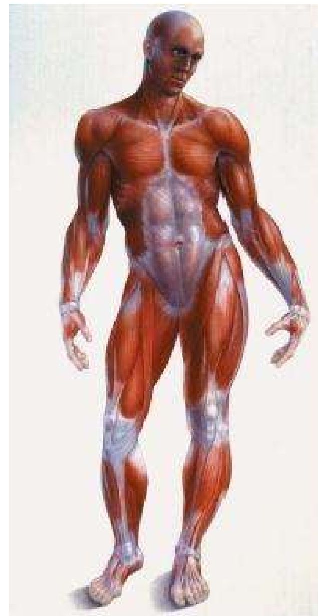
This table shows the four kinds of moveable joints.

Kind of Joint	Where It's Found	How the Bones Move
Pivot joint	Neck	The bones rotate around each other.
Gliding joint	Wrist, ankle	The bones slide over each other.
Hinge joint	Knee, elbow	The bones move back and forth like a door hinge.
Ball-and-socket joint	Shoulder, hip	The bones move in a circle.

Human Organ System

K. Muscular System

The Muscular System



Your muscular system is made of muscles that cause parts of your body to move. Muscles move your bones. They make your heart beat. They make you breathe. They even make the pupils of your eyes become larger or smaller.

Functions of the Muscular System

There are three kinds of muscles in your body. Each kind has different function.

Skeletal muscles move bones. For example, when you kick a soccer ball, skeletal muscles pull on the bones in your lower leg. You can control your skeletal muscles.

Heart muscles make your hear beat and pump blood through your body. You cannot control your heart muscles. Your heart beats automatically without your thinking about it.

Smooth muscles are found in many of your organs. For example, smooth muscles move food through your digestive system. They also let you breathe, cough, and sneeze. Smooth muscles work automatically, but you can control some of them. For example, you can cough on purpose if you want to.

Some Muscles Work in Pairs

Many skeletal muscles work in pairs. When one muscle in the pair contracts, or shortens, the other muscle relaxes.

When your biceps contracts, your triceps relax. Your lower arm is pulled toward your upper arm. When your biceps relaxes and your triceps contracts, your arm straightens. If both muscles contracted at the same time, your arm wouldn't move.

Human Organ System

L. Digestive System

The Digestive System

Before your body can use the food you eat, the food has to be broken down into nutrients. A **nutrient** (NOO tree unt) is a substance that an organism needs in order to survive and grow. Breaking food down into nutrients is the function of your **digestive system**.

The digestive system breaks down food in two ways. First it grinds the food and mashes it into tiny pieces. Then it mixes the food with digestive juices. The digestive juices break the food down into nutrients.

Organs in the Digestive System

Mouth. Digestion begins in your mouth. Your teeth grind up food into smaller pieces. Your tongue moves the pieces around to mix them with saliva (suh LY vuh). Saliva contains a digestive juice that starts breaking down some materials in the food.

Esophagus. When you swallow, food travels through your esophagus (ih SAHF uh gus) to your stomach.

Stomach. Muscles in your stomach churn the food and mix it with more digestive juices. The partly digested food moves from your stomach to your small intestine.

Liver and Gall Bladder. Your liver makes a digestive juice called bile. The bile is stored in your gall bladder. Bile passes through a tube into your small intestine.

Pancrease. Your pancreas (PANG kree us) makes other kinds of digestive juices. They pass through a tube into your small intestine.

Small Intestine. Here, digestive juices from your liver and pancrease finish digesting the food. Nutrients from the digested food move into your blood. Undigested materials move into your large intestine.

Large Intestine. Your large intestine removes water from the undigested material. The water passes into your blood. The solid wastes move into your rectum.

Rectum and Anus. Your rectum stores solid wastes until you are ready to get rid of them. The wastes leave your body through the anus.

Human Organ System

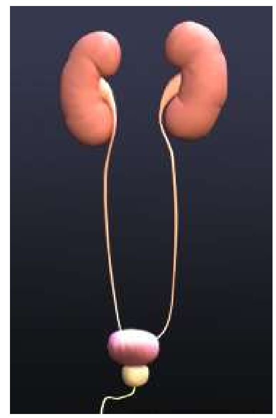
M. Excretory System

As your cells function, they produce wastes. The function of the **excretory** (EK skreh tore e) **system** is to move these wastes out of your body. The parts of the excretory system that do this job include your urinary system, your skins, and your lungs.

Urinary System

The urinary (YUR uh ner ee) system is made of different organs with different functions.

Urinary System



*****Special Remarks*: The excretory system and the digestive system get rid of different kinds of wastes. The excretory system gets rid of wastes that your cells produce. The digestive system gets rid of solid wastes that are left over when you digest food.

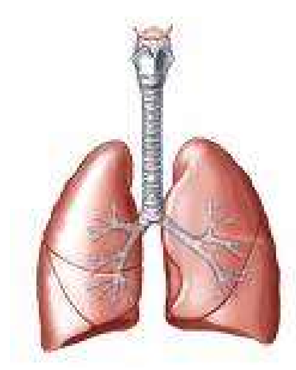
Skin

Your skin is the largest organ in your body. It is the outer covering that protects your other organs and tissues. Your skin is also an excretory organ. Water and wastes leave your skin in perspiration (pur spuh RAY shun).

Sweat gland glands release perspiration through pores to the surface of your skin. There, the perspiration evaporates. The evaporation of perspiration helps keep your body from overheating. Perspiration also contains wastes.

The Lungs

Your cells produce wastes. Two of those wastes are carbon dioxide gas and water. Carbon dioxide and water leave your cells and enter your blood. The blood travels through blood vessels to your lungs. There, the carbon dioxide and water leave your blood and enter your lungs. The liquid water changes to water vapor, which is a gas. Every time you breathe out, carbon dioxide gas and water vapor leave your body.



Human Lungs

Human Organ System

N. Respiratory System

Your **respiratory** (RES pur uh tore e) **system** takes in oxygen and gets rid of waste gases. When you inhale, you take air into your lungs. The air contains oxygen. Your body cells need oxygen to release energy from the nutrients in food. In your lungs, the oxygen passes into tiny blood vessels. Red blood cells pick up the oxygen and carry it to cells throughout your body.

Respiratory System

As your cells use oxygen, they produce two wastes. The wastes are carbon dioxide and water. These wastes leave your cells and enter your blood. Your blood carries the carbon dioxide and water to your lungs.

Important words: **Inhale** means "breathe in".
Exhale means "breathe out."

In your lungs, carbon dioxide and water leave your blood and pass into your lungs. The liquid water changes to water vapor, which is a gas. When you exhale, carbon dioxide gas and water vapor leave your body.

Organs in the Respiratory System

Mouth and Nose. Air enters your body through your nose and mouth. Waste gases from your lungs also leave the same way.

Trachea. Air travels through the trachea (TRAY kee uh) toward your lungs. Wastes gases from your lungs also travel through this tube to the outside.

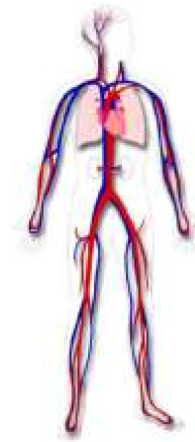
Bronchi. The trachea branches into two tubes called bronchi (BRONG kee). One tube leads to each lung.

Lungs. When you inhale, your lungs take in air. Oxygen in the air moves into your blood. Waste gases move out of your blood into your lungs. When you exhale, these gases leave your body.

Special Comments: You can't see the water vapor in your breath when you exhale. But if you're outside on a cold day, your breath makes a "cloud" in the air. The cloud is made of tiny droplets of water. The cold air made the water vapor in your breath change to liquid water.

Human Organ System

O. Circulatory System



Your **circulatory** (SUR kyuh luh tor ee) **system** moves blood throughout your body. The organs in your circulatory system are your heart and blood vessels. Your blood carries oxygen from your lungs to all your cells. Blood also carries nutrients form your digestive system to your cells. Your blood picks up wastes that your cells produce. It carries these wastes to your kidneys and lungs. Your kidneys are part of your excretory system. Your lungs are part of your respiratory system. But your lungs also function as part of your excretory system. Together, your kidneys and lungs move wastes out of your body.

The Heart

Your heart is an organ about the size of your fist. Its function is to pump blood through your blood vessels.

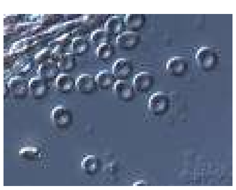
- Blood from all parts of your body enters the right side of your heart.
- The right side pumps the blood out of your heart to your lungs.
- In your lungs, the blood releases wastes and picks up oxygen.
- The blood goes from your lungs to the left side of your heart.
- The left side pumps the blood out of your heart to all parts of your body. The blood delivers oxygen to cells and picks up wastes. Then the blood returns to the right side of your heart again. The cycle repeats over and over.

Blood Vessels

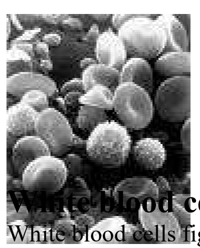
Blood travels away from the heart in **arteries.** The arteries nearest the heart are very large. They get narrower as they branch out to different parts of the body. The narrowest blood vessels are called capillaries. The **capillaries** connect arteries to veins. **Veins** carry blood back to the heart.

Blood

Your blood is made up of solid and liquid parts. The solid parts include red blood cells, white blood cells, and platelets. The liquid part is **plasma**.



Red blood cells
Red blood cells carry oxygen to all parts of the body



White blood cells
White blood cells fight germs that cause disease.

Platelets The platelets play an important role in stopping bleeding and beginning the repair of injured blood vessels.

Human Organ System

P. Nervous System

The Nervous System

Your **nervous system** controls all of your body's activities. None of your other systems would function without your nervous system. The organs in your nervous system are your brain, spinal cord, sense organs, and nerves. Nerves from your sense organs carry information to your brain and spinal cord. Your brain and spinal cord control how you respond to the information.

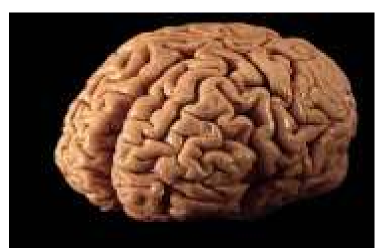
Brain. Your brain is the control center of your body. It gets information from your senses. It controls how you respond to the information. It allows you to think. It stores memories.

Nerves. Nerves are made of nerve cells that transmit messages. They carry messages from all parts of your body to your spinal cord and brain. They carry messages away from your spinal cord and brain to all parts of your body.

Spinal Cord. Your spinal cord is a long bundle of nerves. It runs you're your brain down your back. It is protected by your backbone. Messages to and from your brain travel through your spinal cord. The spinal cord can also receive and send some messages by itself.

The Brain

Your brain is made of three main parts. Each part has different functions.



- Cerebellum – The cerebellum (ser un BEL um) coordinates the movements of your muscles. It also helps you keep your balance.
- Cerebrum – The cerebrum (suh REE brum) controls body movements that you decide to make. It also controls learning, thinking, memory, and imagination. The cerebrum is the part of your brain that receives information from your sense organs.
- Brain Stem – The brain stem controls your breathing, heartbeat, and movements inside your digestive system. This part of the brain functions automatically, even when you are sleeping.

Human Organ System

Sense Organs

Your sense organs are your eyes, ears, nose, tongue, and skin. They get information about your environment and send the information to your brain. Your brain then figures out what the information means and how you should respond.

Human Senses

Sense	Sense Organ	What It Does
Sight	Eye	Detects light and color
Hearing	Ear	Detects sound
Smell	Nose	Detects odors
Taste	Tongue	Detects sweet, salty, sour, and bitter tastes
Touch	Skin	Detects pressure, pain, heat, and cold
Balance	Inner ear	Detects body position

The Human Organ System

Activity 1

1. What is an organism?

2. What is a cell?

3. What are the six (6) characteristics that all living things exhibit?

4. What are two names we use to describe the study of living things?

5. What is the name that we use to classify living things in five (5) large distinct groups?

6. Name one or two characteristics that distinguish **animals** from members of other kingdoms.

7. Name one or two characteristics that distinguish **plants** from members of other kingdoms..

8. Name one or two characteristics that distinguish **fungi** from members of other kingdoms.

9. Name one or two characteristics that distinguish **protists** from members of other kingdoms

10. Name one or two characteristics that distinguish **bacteria** from members of other kingdoms.

11. Name a specific **animal**; draw a picture of the **animal**; describe the animal to the class; and discuss how the **animal** exhibits some of its basic life functions.

12. Name a specific **plant**; draw a picture of the **plant**; describe the **plant** to the class; and discuss how the **plant** exhibits some of its basic life functions.

13. Name a specific **fungus**; draw a picture of the **fungi**; describe the **fungi** to the class; and discuss how the **fungi** exhibits some of its basic life functions.

14. Name a specific **protist**; draw a picture of the **protist**; describe the **protist** to the class; and discuss how the **protist** exhibits some of its basic life functions.

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Part II: Life Science

Lesson 5: Food Chains - Food Webs – Energy Pyramids

Do You Know?

Food chains (other names **food webs**, **food networks** and/or **trophic networks)**, describe the feeding relationships between species to another within an ecosystem. A **food chain** is the flow of energy from one organism to the next as one organism consumes the previous organism as its source of food - energy.

Most ecosystems ultimately rely upon the Sun for energy and upon photosynthetic organisms to harness that energy.

In land-based ecosystems, plants such as grass are the primary producers and form the first trophic level. Next are herbivores (primary consumers) that eat the grass, such as rabbits. Next are carnivores (secondary consumers) that eat the rabbits, such as a bobcats. Next are carnivores (tertiary consumers) that eat the bobcats, such as a mountain lions. Trophic relationships are rarely this simple. Very often they are more of a "web" than a "chain." For example, mountain lions may eat both rabbits and bobcats. The trophic categorization of the mountain lion exists on two levels, possibly more.

Components of ecosystems

We view ecosystems as having four basic components:

A. The abiotic environment
B. Producers
C. Consumers
D. Decomposers

Producers (autotrophs) utilize energy from the sun and nutrients from the **abiotic environment** (carbon dioxide from the air or water, other nutrients from the soil or water) to perform photosynthesis and grow. Producers are generally green plants (with chlorophyll). **Consumers (heterotrophs)** are organisms that feed on other organisms.

Decomposers and detritivores utilize energy from wastes or dead organisms, and so complete the cycle by returning nutrients to the soil or water, and carbon dioxide to the air and water.

In this lesson one can learn many things about the production and recycling of food – energy on earth, in general, and in an ecosystem in particular.

Food Chains - Food Webs – Energy Pyramids

Production of Food, Energy, and Biomass on Planet Earth

Food chains (other names **food webs**, **food networks** and/or **trophic networks)**, describe the feeding relationships between species within an ecosystem. A **food chain** is the flow of biomass energy from one organism to the next as one organism consumes the previous organism as its source of food - energy. Organisms in a food chain are grouped into trophic levels. Each link in this "chain" of consumption is termed a **trophic level.** Because only a fraction of the energy used by organisms at each trophic level is converted to biomass, less energy is available at higher levels.

Solar energy sustains almost all of the 1.8 million species of living things on planet earth; without the sun's energy, life on Earth would cease. Solar energy is converted into chemical energy (in the form of sugar) through the process of photosynthesis, which is performed by plants and other photosynthetic organisms (e.g., cyanobacteria). This is why we call plants and other photosynthetic organisms **producers**. (A few organisms acquire their energy from geothermal processes on the ocean floor instead of from the sun.) Different ecosystems produce different amounts of chemical energy (sugar) because they vary in the amount of sunlight, water and nutrients available to the plants, as well as temperature conditions. Tropical rain forests, for example, are very productive (energy-rich) because these ecosystems get a lot of sunlight, have fairly uniform warm temperatures and receive a great deal of rainfall thus promoting plant growth all year long. In addition, dead matter is rapidly decomposed and nutrients recycled back into the plants. Just the opposite, deserts and frozen areas are very unproductive ecosystems because plants receive limited water and nutrients and are growth-restricted. In summary, the primary production of food - energy is the generation of biomass through photosynthesis. The highest producers (ecosystems) of biomass are

- Tropical rain forests, 2000 $g/m^2/yr$ of biomass
- Swamps and marshes, 2500 $g/m^2/yr$ of biomass
- Algal beds and reefs, 2000 $g/m^2/yr$ of biomass
- River estuaries, 1800 $g/m^2/yr$ of biomass

Others include

- Temperate forests, 1200 $g/m^2/yr$ of biomass
- Cultivated lands; 600 $g/m^2/yr$ of biomass

while lowest producers (ecosystems) are deserts and frozen areas (less than 200 $g/m^2/yr$ of biomass).

Food Chains - Food Webs – Energy Pyramids

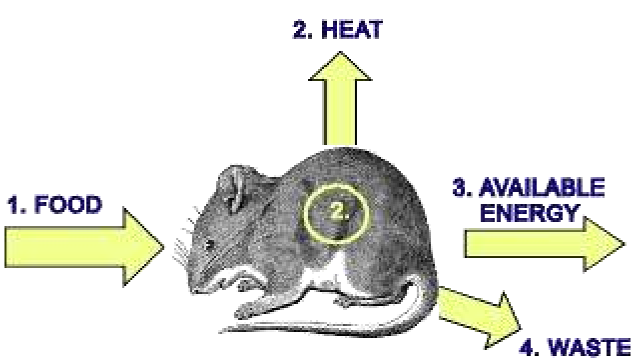
Components of ecosystems

We view ecosystems as having four basic components:

A. The abiotic environment
B. Producers
C. Consumers
D. Decomposers

Producers (autotrophs) utilize energy from the sun and nutrients from the **abiotic environment** (carbon dioxide from the air or water, other nutrients from the soil or water) to perform photosynthesis and grow. Producers are generally green plants (those with chlorophyll). **Consumers (heterotrophs)** are organisms that feed on other organisms

In addition to **producers**, ecosystems also house species called **herbivores** (also called **primary consumer**) that eat photosynthetic organisms in order to obtain the energy and nutrients that they will need to stay alive. In turn, **carnivores** eat herbivores. Carnivores can also eat one another so an ecosystem may have different levels of carnivores – 1st level, 2nd level, 3rd level or secondary, tertiary or quaternary consumers. In the process, energy that is stored in the bodies of each organism flows along a linear feeding relationship (producers, herbivores and a variety of carnivores) that we call a **food chain**. Thus, energy moves in one direction. It is not recycled. At each level much of this energy is lost from the organism's body as heat and with waste matter. As a general rule of thumb, about 10% (5 - 20% range) of the energy taken in is available for the next feeding (**trophic**) level. Since higher trophic levels receive progressively less energy there are fewer species at these levels. As a result food chains rarely go beyond 4 - 5 feeding levels. Humans are generally primary and secondary consumers, and thus represent usually second and third trophic levels. Most humans are **omnivores,** which means they consume both plants and animals. When referring to omnivore from an ecological standpoint it means to consume from different trophic levels. Less energy is required to support vegetarian humans than omnivorous ones, for there is a significant energy loss during the conversion of grain and vegetables in animal matter. **Decomposers and detritivores** utilize energy from wastes or dead organisms, and so complete the cycle by returning nutrients to the soil or water, and carbon dioxide to the air and water.

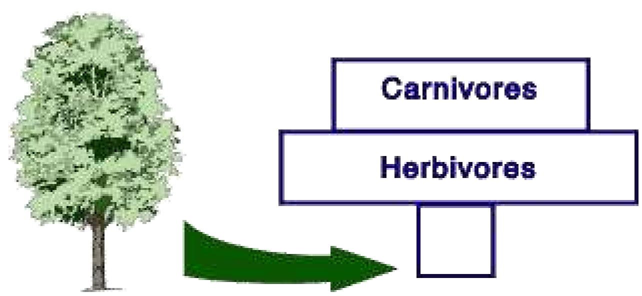


Every level in a tropic pyramid loses 90% of the energy consumed to create heat.

Food Chains - Food Webs – Energy Pyramids

There are two kinds of food chains - **grazing food chains** and **detritus food chains**. Grazing food chains derive their energy directly from the sun. These are the chains of which we are familiar. However, dead matter (**detritus**) is rich in energy and nutrients. Decomposers and detritivores obtain their nutrients and energy from this resource as opposed to the sun. All the organisms feeding on the detritus are part of the **detritus food chain** (rarely mentioned).

Rarely do organisms just eat one type of food.. Some may even eat both animals and plants and are called **omnivores**. If we listed every species that occurred in an ecosystem and then drew arrows connecting them to each of their food sources, we would see so many crisscrossing arrows that it would give the appearance of a spider web. We call the entire complex array of feeding relationships in an ecosystem a **food web,** which do not show the energy that is being lost at each trophic level.



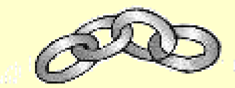
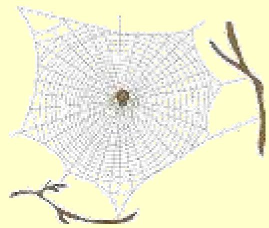
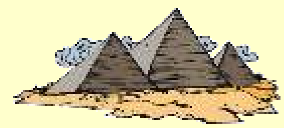
In addition to food chains and food webs, a third way that the flow of energy can be depicted in an ecosystem is to create one of the three types of **ecological pyramids**. A **Pyramid of Numbers** can be generated by counting all of the organisms at the different feeding levels. On occasion this approach will not work. For example, one tree (a producer) can represent an ecosystem and harbor numerous populations of herbivores and carnivores.

A second type of pyramid is a **Pyramid of Biomass** where organisms are collected from each feeding level, dried and then weighed. This dry weight (biomass) represents the amount of organic matter (available energy) of the organisms. While this approach will generally create a pyramid that illustrates energy flow, its use can occasionally also produce an inverted pyramid. In aquatic ecosystems, phytoplankton reproduce and are then eaten rapidly by zooplankton. Therefore, it would be possible to have a few phytoplankton and a lot of zooplankton when a collection is taken.

A third type of pyramid called a **Pyramid of Energy Flow** tends to resolve these problems. This approach necessitates measuring the caloric value of the different organisms that make up the community. It nicely shows how energy is continually decreasing along the food chain from producers to top level carnivores.

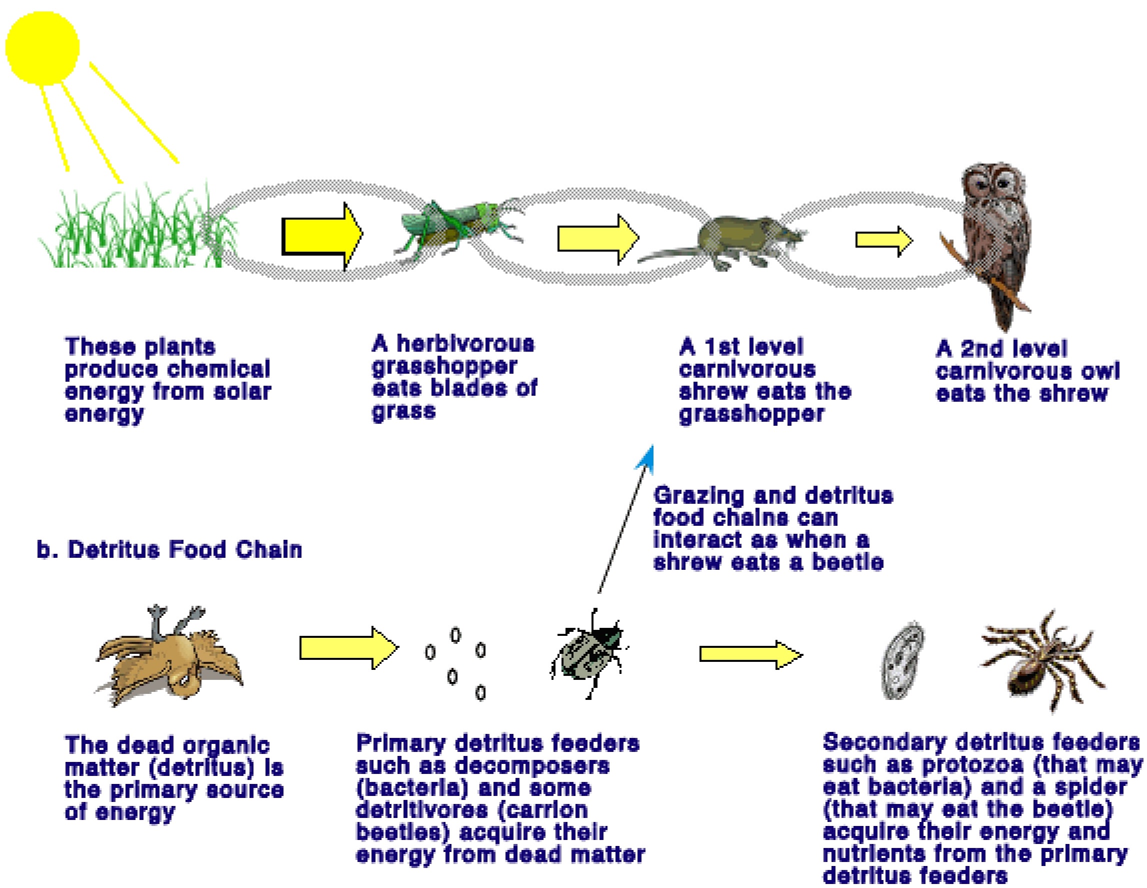
Food Chains - Food Webs – Energy Pyramids

Three Ways That Illustrate How Energy Moves Through an Ecosystem

1. Food Chains	2. Food Webs	3. Ecological Pyramids
		

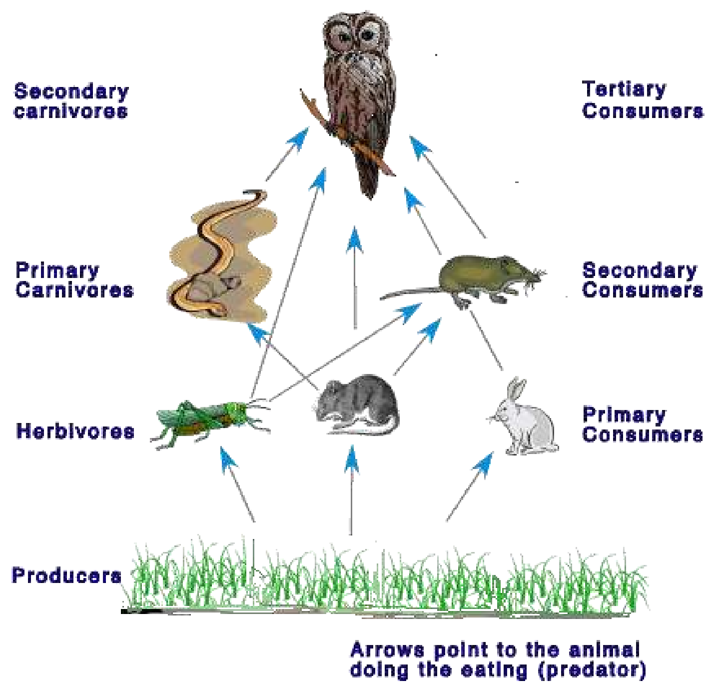
Food Chains

a. Grazing Food Chain

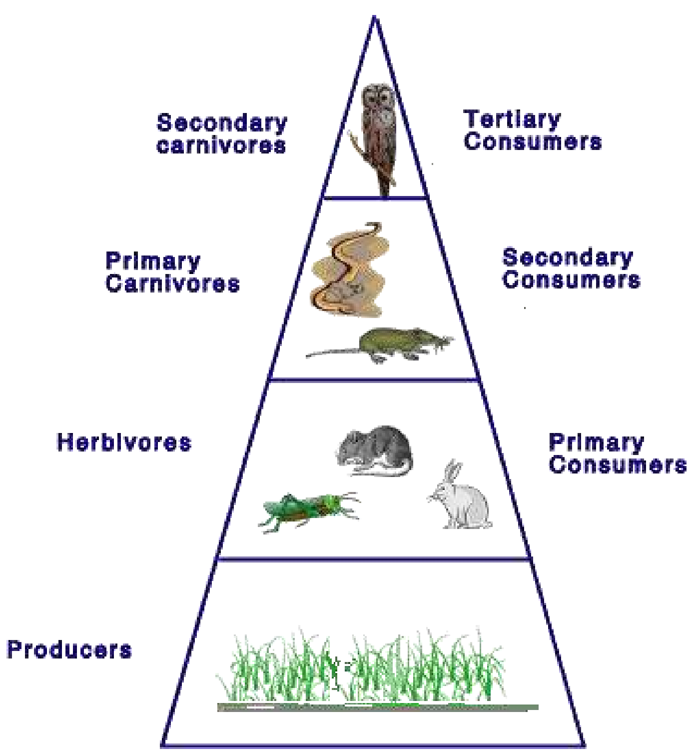


Food Chains - Food Webs – Energy Pyramids

Food Web



Energy Pyramid



Part II: Life Science

Lesson 6: Health and Nutrition

Do You Know?

The World Health Organization (WHO) defined **health** as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity; that includes the ability to lead a socially and economically productive life. In the medical field, the technical term for health is an organism's ability to efficiently respond to challenges (stress) and effectively restore and sustain a “state of balance;" this describes one's overall state as that of doing well or wellness.

Nutrition is the science that examines the relationship between diet and health. Dietitians are health professionals who specialize in this area of study, and they are trained to provide safe, evidence-based dietary advice and interventions.

There are **seven main classes of nutrients** that the body needs: carbohydrates, proteins, fats, vitamins, minerals, fiber and water. It is important to consume these seven nutrients on a daily basis to build and maintain **good health**. **Poor health** can be caused by an imbalance of nutrients, either an excess or deficiency. According to the United Nations World Health Organization (WHO: 1996), more than starvation the real challenge in developing nations today is malnutrition - the deficiency of micronutrients (vitamins, minerals and essential amino acids) that no longer allows the body to continue growth and maintain its vital functions.

Deficiencies, excesses and imbalances in diet can produce negative impacts on health, which may lead to diseases such as cardiovascular disease, diabetes, obesity, osteoporosis, and others. Many common diseases and their symptoms can often be prevented or alleviated with better nutrition. The science of nutrition attempts to understand how and why specific dietary aspects influence health.

In general, eating a variety of fresh, whole (unprocessed) plant foods has proven more favorable to good health than eating a monotonous diet based on processed foods. In particular, consumption of whole plant foods slows digestion and provides higher amounts and a more favorable balance of essential and vital nutrients per unit of energy; resulting in better management of cell growth, maintenance, and mitosis (cell division) as well as regulation of blood glucose and appetite. Generally, a regular eating pattern has proven to be a healthier way of eating.

Health and nutrition specialists who are concerned about healthy living have developed a Food Pyramid, suggesting the food groups that should eaten daily. Moreover, the Food Pyramid suggests the amounts from each food group on a daily basis. From this lesson one can learn many things about healthy living, nutrition and the food groups.

Health and Nutrition

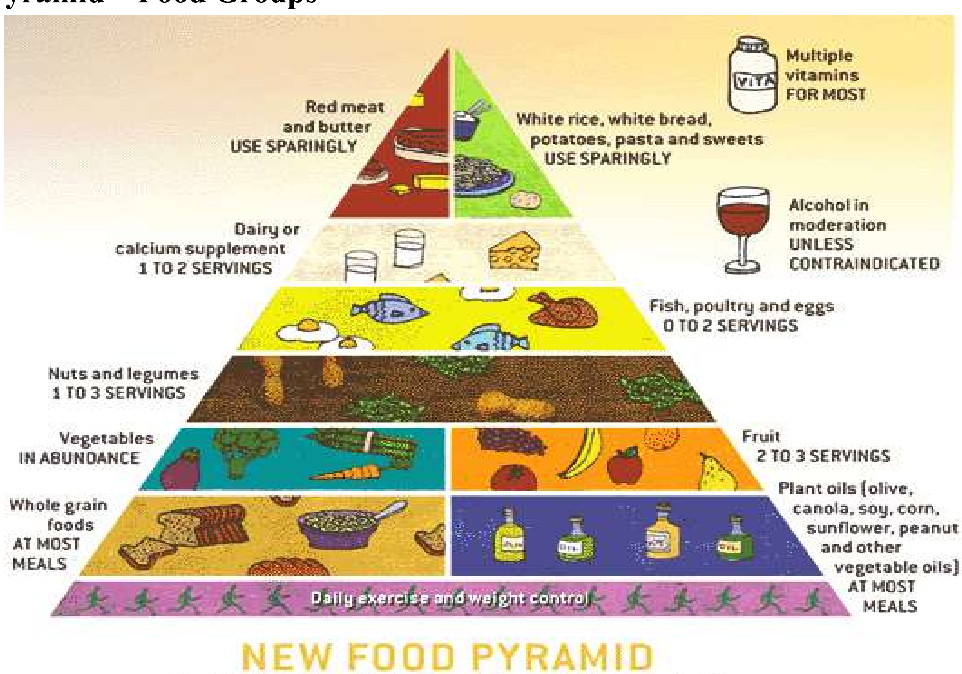
Nutrition

Nutrition is the science that also investigates metabolic and physiological responses of the body to diet. **Metabolism** is the set of chemical reactions that occur in living organisms in order to maintain the life processes. These processes allow organisms to grow, reproduce, maintain their structures, and respond to their environments. Metabolism is usually divided into two categories: catabolism and anabolism.**Catabolism** breaks down large molecules, for example to harvest energy in in cellular respiration. Anabolism cellular respiration. **Anabolism**, on the other hand, uses energy to construct components of cells such as proteins and nucleic acids.

Human being consist of the things that they eat and absorbs into the bloodstream.
Thus nutritionists study what are the things that the body needs in order for it to remain healthy. Nutritionists have learned that there are seven main classes of nutrients that the body needs: carbohydrates, proteins, fats, vitamins, minerals, fiber and water. It is important to consume these seven nutrients on a daily basis to build and maintain health.

Poor health can be caused by an imbalance of nutrients, either an excess or deficiency. According to the United Nations World Health Organization (WHO: 1996), more than starvation the real challenge in developing nations today is malnutrition-the deficiency of micronutrients (vitamins, minerals and essential amino acids) that no longer allows the body to stay healthy, grow and maintain its vital functions.

Food Pyramid – Food Groups



outlined by the authors distinguishes between healthy and unhealthy types of fat and carbohydrates. Fruits and vegetables are still recommended, but the consumption of dairy products should be limited.

Health and Nutrition

Food Groups according to the Food Guide Pyramid

Bread, Cereal, Rice, and Pasta Group

Grain products include foods derived from cereal crops. Cereals, breads, pastas, crackers, and rice all fall under this categorization. Grains supply food energy in the form of starch, and are also a source of protein. Whole grains contain dietary fiber, essential fatty acids, and other important nutrients. Milled grains, though more palatable, have many nutrients removed in the milling process and thus are not as highly recommended as whole grains. Whole grains can be found especially in oatmeal, brown rice, grits, corn tortillas and whole wheat bread. Daily, 6-11 servings of grain products are recommended.

Vegetable Group

A vegetable is a part of a plant consumed by humans that is generally savory (not sweet) and not considered grain, fruit, nut, spice, or herb. For example, the stem, root, flower, etc. may be eaten as vegetables. Vegetables contain many vitamins and minerals; however, different vegetables contain different nutrients, so it is important to eat a wide variety of vegetables. For example, green vegetables typically contain vitamin C, dark orange and dark green vegetables contain vitamin A, and bushy vegetables like broccoli and related plants contain iron and calcium. Vegetables are very low in fats and calories, but cooking can often add fats and calories. It is suggested that one consume 3-5 servings of vegetables each day. They may be fresh, frozen, canned, or made into juices.

Fruit Group

In terms of food (rather than botany), **fruits** are the sweet-tasting seed-bearing parts of plants, or occasionally sweet parts of plants which do not bear seeds. These include apples, oranges, plums, bananas, and ? etc. Fruits are low in calories and fat and are a source of natural sugars, fiber and vitamins. Processing fruits when canning or making into juices unfortunately often adds sugars and removes nutrients; therefore fresh fruit or canned fruit packed in juice rather than syrup is recommended. The fruit food group is sometimes combined with the vegetable food group. It is is suggested for one to consume 2-4 servings of fruit each day. They may be fresh, frozen, canned, dried, or made into juice. Note that many foods that are considered fruits in botany because they bear seeds are **not** considered fruits in cuisine because they lack the characteristic sweet taste.

Milk, Yogurt, and Cheese Group

Dairy products are produced from the milk of mammals, most usually but not exclusively cattle. They include milk and yogurt and cheese. They are the best source for the mineral calcium, but also provide protein, phosphorus, vitamin A, and in fortified milk, vitamin D. However, many dairy products are high in fat, which is why skimmed products are available as an alternative. Daily, 2-3 servings of dairy products are recommended.

Health and Nutrition

Meat, Poultry, Fish, Dry Beans, Eggs, and Nuts Group

Meat is the tissue - usually muscle - of an animal consumed by humans. Since most parts of many types of animals are edible, there is a vast variety of meats. Meat is a major source of protein, as well as iron, zinc, and vitamin B. Meats include beef, chicken, pork, salmon, tuna, and shrimp, etc. However, since many of the same nutrients found in meat are also be found in foods like eggs, dry beans, and nuts, such foods are typically placed in the same category as meats, as **meat alternatives**. These include **tofu**, products that resemble meat or fish but are made with soy, eggs, and cheeses. Although meats provide energy and nutrients, they are often high in fat and cholesterol, and can be high in sodium. Simply trimming off fatty tissue can go a long way towards reducing this negative effect. Daily, 2-3 servings of meat or alternatives are recommended. For those who are ethically opposed (*Vegetarias and Taboo food and drink persons*) to consuming meat or animal products, meat analogues such as tofu are available to fill this nutritional need.

Fats, Oils, and Sweets

Fats, Oils, and Sweets are at the top of the food pyramid because it is the smallest section, indicating that, while they do have nutritional value, they should be used sparingly.

Nutrients

Let us examine closer **the seven main classes of nutrients that the body needs on a daily basis: carbohydrates, proteins, fats, vitamins, minerals, fiber and water;** according to most nutritionists.

Carbohydrates may be classified as monosaccharides, disaccharides, or polysaccharides by the number of sugar units they contain. Monosaccharides contain 1 sugar unit, disaccharides contain 2, and polysaccharides contain 3 or more. Polysaccharides are often referred to as complex carbohydrates because they are long chains of sugar units, whereas monosaccharides and disaccharides are simple carbohydrates. The difference is important to nutritionists because complex carbohydrates take longer to metabolize since their sugar units are processed one-by-one off the ends of the chains. Simple carbohydrates are metabolized quickly and thus raise blood sugar levels more quickly resulting in rapid increases in blood insulin levels. There is scientific evidence that indicates that reduced insulin function (i.e. **insulin resistance**) as a major factor for the development of many diseases; examples: chronic inflammation, which in turn is strongly linked to a variety of adverse developments such as arterial and clot formation (i.e**. heart disease**), exaggerated cell division (i.e. **cancer**), **abdominal obesity**, **elevated blood sugar**, **elevated blood pressure**, **elevated blood triglycerides**, **reduced HDL cholesterol** and **type 2 diabetes.** There are also other dietary factors that may contribute to the development of insulin resistance.

Health and Nutrition

Many meats, especially chicken, contain all the essential amino acids needed by humans.

Protein is composed of amino acids, that provide essentials that are required to maintain good body structure (muscles, skin, hair etc.). The body requires amino acids to produce new body protein (protein retention) and to replace damaged proteins (maintenance) that are lost in the urine. Maintaining a diet that contains adequate amounts of amino acids is particularly important for growing animals, whohave a particularly high requirement. Common dietary sources of protein include meats, eggs, grains, dry fruits, and dairy products such as milk and cheese.

Fats are composed of fatty acids, long carbon/hydrogen chains bonded to a glycerol. Fat may be classified as saturated or unsaturated. **Saturated fats** have all of their carbon atoms bonded to hydrogen atoms, whereas **unsaturated fats** have some of their carbon atoms double-bonded in place of a hydrogen Most fatty acids are non-essential, meaning the body can produce them as needed, however, at least two fatty acids are essential and must be consumed in the diet. An appropriate balance of essential fatty acids omega-3 and omega-6 fatty acids (certain families of polyunsaturated fats) - have been discovered to be important for maintaining good health. Both of these unique "omega" long-chain polyunsaturated fatty acids are important for functions such as the development and function of hormones. Also the general composition of a diet determines health implications in relation to essential fatty acids, inflammation (e.g. immune function) and mitosis (i.e. cell division).

Mineral and/or vitamin deficiency or excess may yield symptoms of diminishing health such as **osteoporosis** (bone disease), weak immune system, disorders of cell metabolism, certain forms of **cancer**, symptoms of premature aging, and poor psychological health (i.e. eating disorders), and others. As of 2005, twelve vitamins and about the same number of minerals were recognized as "essential nutrients", meaning that they must be consumed and absorbed to prevent deficiency symptoms and death. Dietary minerals and vitamin are the chemical compounds required by living organisms, other than the four elements carbon, hydrogen, nitrogen, and oxygen which are present in common organic molecules. For examples, the body needs **calcium** (for muscle and digestive system health, builds bone, neutralizes acidity, clears toxins, helps blood stream), **magnesium** (for building bones, increasing flexibility, etc.), **Potassium** (for heart and nerves health), and **iron** (for many proteins and enzymes, notably hemoglobin).

Health and Nutrition

Dietary fibre consists mainly of cellulose that is indigestible because we do not have enzymes to digest it. Fruits and vegetables are rich in dietary fibre. Fibre is important for providing bulk to the intestinal contents and for stimulating peristalis (rhythmic muscular contractions passing along the digestive tract). Lack of dietary fibre in the diet leads to **constipation** (failure to pass motions – unable to discharge solid waste).

Manual water pump

Water - About 70% of the non-fat mass of the human body is made of water. To function properly, the body requires between one and seven liters of water per day to avoid dehydration; the precise amount of water needed depends on the level of activity, temperature, humidity, and other factors. With physical exertion and heat exposure, water loss will increase and daily fluid needs may increase as well. It is not clear how much water intake is needed by healthy people, although some experts suggest 8–10 glasses of water (approximately 2 liters) daily is the minimum to maintain proper hydration. The "fact" that a person should consume eight glasses of water per day cannot be traced back to a scientific source. For those who have healthy kidneys, it is rather difficult to drink too much water, but (especially in warm humid weather and while exercising) it is dangerous to drink too little.

World Health Organization (WHO)

The WHO's constitution states that its objective "is the attainment by all peoples the highest possible level of health." Its major task is to combat disease, especially key infectious diseases, and to promote the general health of the people of the world. The World Health Organization is one of the original agencies of the United Nations. As well as coordinating international efforts to monitor outbreaks of infectious diseases, such as SARS, malaria, and AIDS, the WHO also sponsors programs to prevent and treat such diseases. The WHO supports the development and distribution of safe and effective vaccines, pharmaceutical diagnostics, and drugs. After years of fighting smallpox, the WHO declared in 1979 that the disease had been eradicated - the first disease in history to be eliminated by human effort. The WHO is nearing success in developing vaccines against malaria and aims to eradicate polio within the next few years. The organization has already endorsed the world's first official HIV/AIDS Toolkit for Zimbabwe (October 3, 2006), making it an international standard.

Part II: Life Science

Lesson 7: Reproduction of New Life by Living Things (Producing Offspring)

Do You Know?

In biology, reproduction is the process by which a living organism(s) produces other organisms more or less similar to itself. The ways in which species reproduce differ, but the two main methods of reproductions by all organisms are by asexual reproduction or sexual reproduction. **Asexual reproduction** involves only one parent without the formation of sex cells (gametes): the parent's cells divide by mitosis to produce new cells with the same number and kind of chromosomes as its own. Thus offspring produced asexually are clones of the parent and there is no variation. **Sexual reproduction** involves two parents, one male and one female. The parents' sex cells divide by **meiosis** (in halves), producing **gametes** (sex cells), which contain only half the number of chromosomes of the parent cell. In this way, when two sets of chromosomes combine during fertilization, a new combination of genes is produced. Hence the new organism will differ from both parents, and variation is introduced. **The ability to reproduce is considered one of the fundamental attributes of living things.**

Sexual Reproductive Systems exist in both plants and animals. The plant organs concerned with sexual reproduction are found in the flowers. These consist of the **stamens** (male organ) and **carpels** (female organs). For animals, we consider the mammals. In male mammals, the reproductive system consists of the **testes**, which produce sperm, the sperm duct and the **penis**, the external part through which the sperm is released. In female mammals, the reproductive system consists of the **ovaries**, which produces eggs, the **fallopian tubes**, through which the eggs travel and the **uterus** where the eggs remain until they are fertilized or discharged from the body.

Hermaphrodites are organisms that are bisexual, where an individual organism has both male and female sex organs. Among animals, such organisms are earthworms. Moreover, there are plants species, such as corn, which has both stamens and carpels on the same individual plant. Such plants are called **monoeious species**. Many plants are of this type species. However, there are other type species of plants, called **dioecious species** (such as willow and holly), where the male and female flowers are on different plants and are not on the same one.

In this lesson one can learn how plants and animals reproduce their off springs. In particular, one will learn details as to how mammals (especially humans) reproduce.

Reproduction of New Life by Living Things (Producing Offspring)

Asexual Reproduction

Asexual reproduction occurs primarily in lower animals, micro-organisms, and plants. In lower animals and micro-organisms, the chief methods of reproduction are by binary fission, fragmentation, and budding. **Binary fission** occurs in unicellular organisms, such as protozoans and bacteria: the nucleus of the parent cell divides to form two new daughter cells. Where more than two new cells are formed, this is termed "**multiple fission.**" **Fragmentation** occurs in some invertebrates, such as jellyfish: parts of the organisms break away and subsequently differentiate to form new organisms. **Regeneration** may sometimes occur before separation, producing chains of offspring budding from the parent organism.

The main methods of asexual reproduction in plants are by vegetative reproduction and the formation of sexual spores. In **vegetative reproduction**, or **propagation**, new plants are produced from the outgrowth of the old ones, such as by the growth of stems, bulbs or by cutting and grafting. **Spore formation** occurs in plants such as mosses and ferns; it also occurs in fungi, bacteria, and some protozoans. The spore may develop into an organism resembling the parent, or into another stage in the life cycle. Some organisms, such as aphids, reproduce by **parthenogenesis**; this is a degenerate form of sexual reproduction in which the unfertilized female's eggs develop directly into new organisms without contribution from the male.

Sexual Reproduction in Plants

Seed-bearing plants (spermatophytes) are divided into two classes: **flowering plants (angiosperms**) and **cone producing plants** (**gymnosperms**) whose seed develop inside of ovaries, like in cones. **In flowering plants, the function of a flower is reproduction**. Despite the enormous variety of flowers, they all contain parts that produce gametes (sex cells) for sexual reproduction. On the outside of the flower are **sepals**, which provide protection while it is in bud. Inside the sepals lie the petals, usually brightly colored in order to attract insects to the **nectar (**a gland at the base of the petals which produces a sugary liquid, nectar, on which the insects feed). Inside the petals are the stamens; these are long filaments, each with an anther at the top containing pollen grains; this is where the male gametes are found. The female part of the flower, the carpel, lies at the centre; it consists mainly of an ovary within which are many ovules containing the female gametes. Before fertilization can take place, pollination must occur – that is, the pollen containing the male gametes must be transferred from the anther to the stigma in order to reach the ovules inside the carpel. This may happen by the wind blowing the pollen onto the stigma, or by the accidental transfer of pollen when insects are feeding on the flower's nectar. Once fertilization has taken place, the zygote divides and forms an embryo inside the ovule, which increases in size as the embryo develops and becomes a seed. Upon germination, the embryonic shoot and root emerge from the Seed to develop into a new plant.

Reproduction of New Life by Living Things
(Producing Offspring)

The primary cone - bearing plants (gymnosperms) are cycads and conifers. These plants carry both male cones and female cones and, like flowering plants, pollen is transferred both by the wind and by insects. Gymnosperm means 'naked seed', and in these plants the ovules, and the seeds into which they develop, are not enclosed in ovaries but are borne unprotected on the scales of their cones.


a cyclad (a palm like tree) Conifers

Sexual Reproduction in Animals in General

The fusion of the sperm nucleus and egg nucleus in the female's oviduct produces a fertilized egg (**zygote**), which divides by mitosis to form an (**embryo)** the early development of a fertilizes egg or offspring. Most mammals produce several young at a time; humans are unusual by normally producing only one offspring at a time. Occasionally humans produce two or more offspring at the same time. When a zygote divides after fertilization to produce separate embryos with genetically identical characteristics, these are described as **monozygotic** (**identical twins**). **Dizygotic** embryos form from separately fertilized eggs and therefore differ genetically (non-identical twins).

Sexual Reproduction in Fish

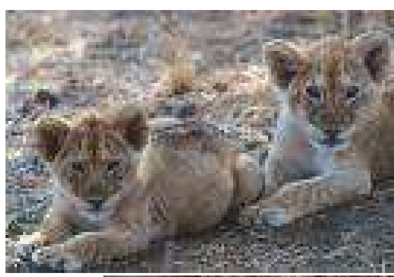
Reproduction in fish is mainly by external fertilization, or spawning. The females, which carry enormous numbers of eggs in their ovaries, lay their eggs in the water, and the male releases sperm onto them. The eggs contain yolk which supplies the embryo with food, and **albumen** – a **protein**– which protects it. The embryo obtains its oxygen from the water by diffusion, and the young fish, or larvae, hatch after a few days. In cartilaginous fish, such as sharks, the eggs are fertilized internally and hatch inside the body.

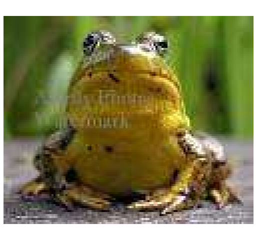
Reproduction of New Life by Living Things
(Producing Offspring)

Sexual Reproduction in Amphibians - Similar to fish, fertilization in amphibians (such as frogs, toads, salamanders) is usually external. Their larvae are aquatic, having gills for respiration. Upon metamorphosis to adult land form, the tail is absorbed into the body and the gills are replaced by lungs.

Sexual Reproduction in Birds - All birds use internal fertilization. The sperm is passed from the male bird into the female's oviduct. The fertilized egg then travels down the oviduct and, as it does so, the walls of the oviduct secrete a layer of albumen which surrounds the yolk. Just before the egg is laid, the oviduct walls secrete a calcium-rich substance over it which hardens into the shell. The embryo obtains its oxygen by diffusion through the shell and membranes.

Sexual Reproduction in Mammals - Fertilization in all mammals is internal. The embryo may develop within a soft-shelled egg, as in the the case of **marsupials** (mammals with a pouch); the kangaroo is an example. For marsupials, immature live offspring or embyros are produced which complete their development within a **marsupium** (pouch). However, for the majority of mammals, the embryos develop within the mother's uterus, where they are protected and nourished by embryonic membranes and a placenta until birth. Such mammals, including humans After birth the young mammals are fed on milk produced by the mother's mammary glands.



frog and tadpoles

Reproduction of New Life by Living Things (Producing Offspring)

Sexual Reproduction in Humans

Human reproduction begins as internal fertilization by the way of intercourse. In its biological sense, **intercourse** is the act by which the male reproductive organ enters the female reproductive tract. It is some time called **copulation** or **coitus.** During this process, the erect penis of the male is inserted into the female's vagina until the male ejaculates semen, which contains sperm, into the female's vagina. The sperm then travels through the vagina and cervix into the uterus or fallopian tubes for fertilization of the female reproductive cell (egg) called the **ovum**. Upon successful fertilization and implantation, carrying of embryo or fetus then occurs within the female's uterus. For approximately nine months, this process is known as pregnancy in humans (women). Pregnancy ends with birth, the process of **birth** is known as labor. **Labor** consists of the muscles of the uterus contracting, the cervix dilating, and the baby passing out of the body through the vagina. In many societies (for medical and legal discussions), human pregnancy is somewhat arbitrarily divided into three trimester periods, as a means to simplify reference to the different stages of prenatal development. The first trimester carries the highest risk of miscarriage (natural death of embryo or fetus). During the second trimester, the development of the fetus can be more easily monitored and diagnosed. The beginning of the third trimester is often considered the point of viability, or the ability of the fetus to survive, with or without medical help, outside of the uterus. After Labor and a live birth of a baby has occurred. It is said that a baby has been born. Human's babies and children are nearly helpless and require high levels of parental care for many years.

Sexual Intercourse – Risk of Contracting Infectious Diseases

Most humans participate in sexual intercourse for pleasure, rather than reproduction.
In fact, most times when humans engage in sexual intercourse they try to avoid pregnancy. Another thing that humans should try to avoid is the contacting of Sexually Transmitted Diseases. How does one avoid contacting Sexually Transmitted Diseases - STD:

A. It is suggested that one does not engage in sexual intercourse before marriage or before a serious adult relationship with commitments.
B. It is suggested that other than in a marriage, that one or both partners should use a condom or other approved protection against sexually transmitted diseases.
C. It is suggested that each partner be honest with the other partner and truthfully discuss his/her sexual history; if there are concerns, each should take medical tests to determine if either has already contacted a sexually transmitted diseases.
D. Get medical treatment for an existing sexually transmitted disease and become cured, if feasible, before engaging in sexual intercourse again.

Reproduction of New Life by Living Things
(Producing Offspring)

Some of the common Sexually Transmitted Diseases (STD) that persons need to try and avoid:

Syphilis
Canker Sores (soft ulcus)
Chlamydia or Infections of Chlamydia
Genital Herpes
Trichomonase
Gonorrhea
Venereal Lympoids
Hepatitis B (HBV) and Hepatitis C (HCV)
Genital Condylome
The Candidose
HIV - AIDS

Stages of the Human Life Cycle

The Life Cycle of a human is a biological and psychological part of every human's existence. Across cultures humans mark life cycle changes through rituals and ceremonies. People study the life cycle through rituals, religious, philosophical, biological and psychological points of view, as well as through works of art, in order to gain a better appreciation for each of the different cycles and to better understand human nature.

Chronological Human life Cycle from Conception until Death

- **Zygote Conception a few seconds -** Recombination
- **Embryo -** 1 day-2 mo 2 months Development
- **Fetus -** 2-9 mo 7 months Growth
- **Birth**
- **Infant -** 0-14 mo - totally dependent upon mother
- **Toddler -** 14-24 mo entering human society
- **Child -** 2-13 yrs 11 yrs uses language
- **Adolescent -** 13-17 yrs 5 yrs sexual maturity
- **Adult -** 18+ years 60+ years most child-rearing,
- **Senior citizen -** 60 years – 75 + years
- **Death**



Part II: Life Science

Lesson 8: Genetics and Heredity

Do You Know?

Genetics is the science that studies heredity. **Heredity** is the process by which characteristics are passed from parents to offspring (**progeny**), so that the progeny resembles the parents. The main concept in genetics is that inheritance is controlled by a set of **genes**, which are discrete physical molecules (**DNA,** chemically known as deoxyribonucleic acid) linked together in long polymer chains to form **chromosomes**.

The first geneticists were interested in how genes were transmitted from parents to progeny during reproduction. They were also interested in how different genes act together to control what we saw in a variety of traits (e.g. height, color, shape, size, etc, known as **phenotypes** - "observed traits"). **Gregor Mendel** asserted a theory of the "Laws of Genetics" which he demonstrated through painstaking experimentation. He illustrated relationships between sets of genes and the physical characteristics that were observed. Although this work was done in the mid -1800's his work was not really recognized until about 1900. Mendel lived in a monastery and his work was not done at a famous university or scientific center; this might have influenced the lack of attention earlier. The principles of the Laws of Genetics remain essentially intact today as Mendel presented them. They outlined the fundamental principles of genes and their relationships to inheritance. The importance of Mendel's contributions to genetics was profound. Current studies in genetics today are built on Mendel's inheritance patterns. Mendel's experiments removed the mystery of heredity and demonstrated that genetic inheritance followed predictable rules.

A change of emphasis in the study of genetics occurred in the 1930's, when science started to recognize that the chemistry of an organism could be studied directly. This fundamental change brought about the realization that genes, like any other components/molecules in an organism, could be studied directly by physical and biochemical methods.

In this lesson one will have the opportunity to learn about inheritance, how parents pass traits and characteristics to an offspring; especially, how this occurs for humans.

Genetics and Heredity

Molecular Biology

In recent years, a new branch of genetics, called **molecular biology**, was "formed" with a major goal of being able to understand the chemical nature of genes. This new approach to the study of genetics led to new concepts and ideas, and soon geneticists ceased to regard individual genes as only units of inheritance, and began to realize that they were units of complete "biological information." These genes contained the entire complement of biological and chemical information required to construct a living, functioning example of the organism to which they belong. The goal of Geneticists and Molecular Biologists in the last half century has been to understand the manner in which this detailed information is made available to the living organism.

DNA, the essence of inheritance

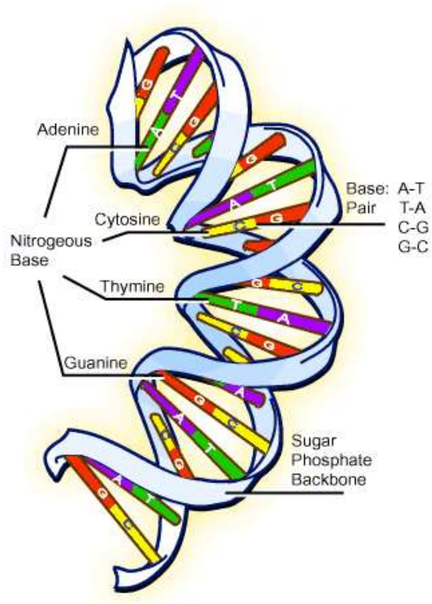
It has been well established that DNA is the chemical basis of genes. James Watson and Francis Crick performed famous experimentation in the early 1950's which led to the discovery that DNA was a double helix (i.e. the genetic material coiled around each other). Watson and Crick shared the Nobel Prize in 1962 with this discovery.

DNA is a long polymeric molecule made up of individual **nucleotides** joined in chain-like fashion to form one strand of the DNA double helix. This nucleotide is actually a complex molecule made of three distinct chemical components: a sugar molecule (specifically, 2'-deoxyribose in the case of DNA), a nitrogenous base molecule (specifically there are four "varieties:" adenine, guanine, thymine, and cytosine), and a phosphoric acid molecule. The sugar joined with the nitrogen base is called a **nucleoside**. The nucleoside joined with the phosphoric acid molecule is called the nucleotide.

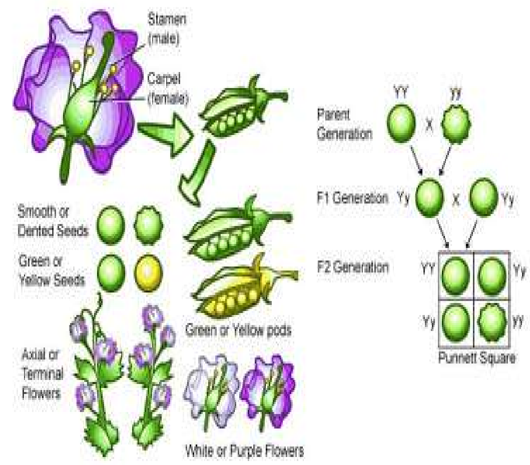
Individual nucleotides monomers (single nucleotide molecules - "mono" means single) are joined together to form a polymer, by attaching one nucleotide monomer to the next in a sequence. Realizing that any one position of a nucleotide in a DNA chain could be one of four nucleotides ("A" for adenosine, "G" for guanosine, "C" for cytosine, and "T" for thymidine), one begins to recognize that the DNA chain is coding a very specific sequence depending on the combinations and lengths of the nucleotides strung together. This is the variability of DNA that enables the genetic material to exist in an almost infinite number of forms.

During reproduction, the DNA chain is copied, and those daughter copies are split and separated into the egg and sperm sexual gametes. The individual gametes from the two parents join together to produce the fertilized ovum, creating a new DNA for the offspring.

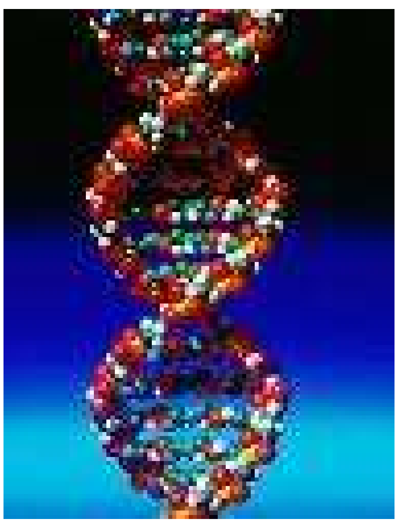
Genetics and Heredity

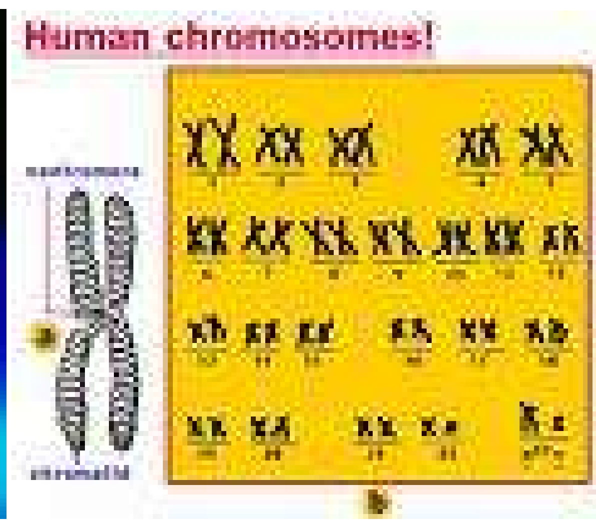


DNA



Mendel's Experiment with Genetics





Human chromosomes (24)

human genes

Genetics and Heredity

Phenotype vs. Genotype

A **gene** is a locatable region of genomic sequence, corresponding to a unit of inheritance, which is associated with regulatory regions, transcribed regions and/or other functional sequence regions. The physical development and phenotype of organisms can be thought of as a product of genes interacting with each other and with the environment. In cells, genes consist of a long strand of DNA that contains a **promoter**, which controls the activity of a gene, and coding and non-coding sequence. A **Coding sequence** determines what the gene produces, while non-coding sequence can regulate the conditions of gene expression. In genetics, what is seen is described as "observable traits", called the **phenotype**. Underlying this phenotype is a set of set of genes which are expressed in biochemical and physical terms giving us these observed traits. DNA strands contain two alleles for any specific gene. This gene "set" (the two alleles) is called the **genotype**, and each single allele may come in two different forms.

Genetic allele types generally have a hierarchy of expression when seen in their phenotype. The allele that is **dominant** is the allele which, if present in a single dose, will alleviate the presence of other gene allele types. An allele that is **recessive** is an allele which needs to be present is a double dose to be observed. A recessive allele, when present in a single dose has no affect, compared to the existence of a dominant allele.

Very often, "letter" symbols are used to designate each of the individual alleles of the gene set, so you can easily see the genotype variation within an inherited condition. The dominant version of the gene allele is generally expressed with a capital letter (e.g. "B"), whereas the recessive version of the gene allele is generally expressed with a lower case letter (e.g. "b"). Some alleles exist in multiple variants, in which case there generally is a relative dominance/recessive hierarchy, and "letter designations" will have superscript notations to give that extra variant its identity.

Let us illustrate how the dominant and recessive gene alleles work in determining a particular trait for an offspring. For simplicity sake, suppose that an individual's height is controlled by one gene location, and there are two alternatives to a gene. Medium height (being dominant) and is expressed as "Y", while tall (being recessive) and is expressed as "y". Since there are two alleles at this gene, the genotypes can be among the following possibilities: "YY", "Yy", "yY", or "yy." Since "Y" is dominant, the height in the example will be medium height for "YY", and "Yy"/"yY". Tall height, since "y" is recessive, will only be observed when the genotype "yy" exists. Where the genotype contains two of the same alleles (in this case either "YY" or "yy") it is called **homozygous**. Where the genotype contains different Variants of the gene alleles (in this case either "Yy" or "yY"), it is called **heterozygous.**

Genetics and Heredity

Inheritance of Traits in Humans – Human Chromosomes – Human DNA - Genes

Scientists, enabled by the Human Genome Project, are currently churning out an unprecedented volume of data on human chromosomes and the tens of thousands of genes residing on them. The completion of the human DNA sequence (The Human Genome Project – HGP) in the spring of 2003 coincided with the 50th anniversary of Watson and Crick's description of the fundamental structure of DNA. The analytical power arising from the reference DNA sequences of entire genomes and other genomics resources has jump-started what some call the "biology century."

There are 24 distinct human chromosomes: 22 autosomal chromosomes, plus the sex-determining X and Y chromosomes. The **XY sex-determination system** is the sex-determination system found in humans, most other mammals, some insects (*Drosophila*) and some plants (*Ginkgo*). In the XY sex-determination system, females have two of the same kind of sex chromosome (XX), and are called the homogametic sex. Males have two distinct sex chromosomes (XY), and are called the heterogametic sex. The chromosomes 1–22 are numbered roughly in order of decreasing size. Somatic cells usually have 23 chromosome pairs: one copy of chromosomes 1–22 from each parent, plus an X chromosome from the mother, and either an X or Y chromosome from the father, for a total of 46.

There are an estimated 20,000–25,000 human protein-coding genes. Human genes are distributed unevenly across the chromosomes. Each chromosome contains various gene-rich and gene-poor regions. Most studies of human genetic variation have focused on single nucleotide polymorphisms (SNPs), which are substitutions in individual bases along a chromosome. Most analyses estimate that SNPs occur on average somewhere between every 1 in 100 and 1 in 1,000 base pairs in the human genome, although they do not occur at a uniform density.

Mendelian Inheritance in Humans

Many human traits follow Mendelian inheritance predictions. Most appear to be "controlled" by a single gene that has two alternative alleles (specific forms of a gene). In each, one allele is dominant and the alternative is recessive. Your genotype is the specific combination of alleles you inherit from your biological parents. It can be homozygous dominant, heterozygous or homozygous recessive.

Part II: Life Science

Lesson 9: Microorganisms - Immunization - Fermentation

Do You Know?

The world of living things includes organisms of all sizes, shapes, colors and cell composition (from one cell organisms to organisms with billions and billions of cells). When scientists (biologists) study living things, they first classify living things in groups with similar major attributes. In Lesson 1, we observed that the highest level of classification of living things is in groups called <u>domains</u> or groups called <u>kingdoms</u>. Every organism belongs to one and only one kingdom. There exist five (5) different kingdoms in which all living things are classified. The kingdoms are: bacteria, protist, fungus, plant, and animal. In Lesson 1, it was stated that the first two (2) kingdoms, just listed, consist of one-cell organisms and the third, fungus, consist of one-cell organisms and some many-cell organisms. In this lesson, we study the organisms in the three (3) kingdoms: bacteria, protist, and fungus, primarily they are one cell animals.

Most of the microorganisms that we will study in this lesson are single-celled organisms. They are the smallest of the small and the simplest of the simple of organisms. They are both **solitary** and **colonial** in their existence. For example, a protist (protozoan, like an amoeba) might spend its entire life alone, just moving through the water. Other **microbes** (microorganisms), like some fungi, may work together in colonies to help each others to survive.

Microorganisms can be **autotrophic or heterotrophic.** That is, they can make food for themselves (auto) as plants do or they can eat other things (hetero) as animals do.

They can reproduce **asexually** or **sexually**. Sometimes a microbe splits into two identical pieces by itself (asexual reproduction). Sometimes the **DNA** (the total set of all life qualities and attributes of an organism) of two different microbes of the same kind mix and a new microbe of that kind is produced (sexual reproduction).

There are good microbes that are very helpful to the survival of plants, other animals and humans. There are bad microbes that are can be destructive, hurtful and even fatal (kill) to the survival of plants, other animals and humans. Some bad microbes are called **germs.**

An important fact is that these microbes make up the largest number of organisms on planet earth; there are trillions of trillions of microbes on the planet earth. They live everywhere on earth, in water and beneath the surface of the earth. Humans and other organisms can not live, as we know life, without these organisms.

Microorganisms are very important in causing and preventing diseases and as decomposers. In this lesson one learns many things about microorganisms on the world.

Microorganisms - Immunization - Fermentation

Microbes

A cluster of *Escherichia coli* bacteria magnified 10,000 times.

A **Microbe** is an organism that is microscopic (too small to be seen by the human eye). Microbe is another common name for microorganism. The study of microbes or microorganisms is called **Microbiology**. Microbes include archaea, bacteria, protists and many fungi. Microbes do not include viruses and prions; which are generally classified as non-living things. Most microbes are single-celled or **unicellular** organisms. A few unicellular organisms are visible to the average human. Microbes live almost everywhere on earth where there is water that is not frozen. Microbes live in rivers, streams, hot springs, on the ocean floor and deep inside of rocks below the earth's surface. Microbes serve many important purposes in **ecology** or different **ecosystems**.

A very important purpose of microbes is the critical roles they play in the recycling of nutrients in ecosystems. They act as decomposers. Another important role of microbes is that they play in the Nitrogen Cycle. Microbes can "fix" nitrogen. Those are two of the positive things that microbes do. However, microbes can also be fatal to humans and other living things. **Pathogenic** (germs) microbes can invade plants, other animals and humans and cause diseases that kill millions of humans each year.

The History of Microorganisms

It is believed that single-celled microorganisms were the first forms of living things on earth. Some believe that they have existed on earth for three (3) to four (4) billions of years; suggesting that for the longest period of life form on earth, the life forms has been microorganisms. There are scientists who have produced some evidence that bacteria and fungi actually existed some 220 million years ago.

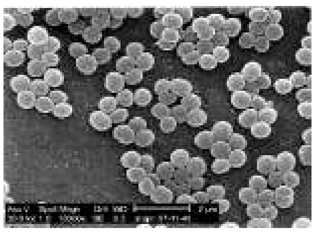
There were many who speculated that microbes existed during the late Middle Age during the **Bubonic Plague** (Black Death) when hundreds of thousands of people died. However, humans did not observe microbes or establish that they actually exist until the 17^{th} Century when the microscope was first invented (1673) by a scientist named Anton van Leeuwenhoek. In 1675, Leeuwenhoek discovered with his microscope that there were forms of life not visible to the naked eye. Louis Pasteur later established by scientific experiments that life-forms did not spontaneously appear from non-living things during the process of things spoiling. Louis Pasteur established that things became spoiled by microbes. In 1876, Robert Koch established, by scientific experiments, that microbes could cause diseases. These early experiments regarding microbes are still the basis of our thoughts that govern the study and practice of microbiology and medicine today. They have helped to discover lots of diseases and cures.

Microorganisms - Immunization - Fermentation

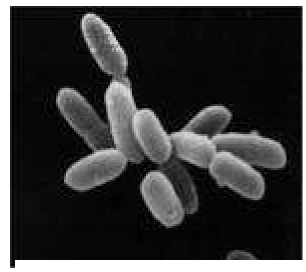
Classification of Microbes

Prokaryotes

Prokaryotes are microorganisms that have cells without an organized nucleus. Prokaryotes are almost always single-celled, although some such as myxobacteria can aggregate into complex structures as part of their life cycle. Prokaryotes are divided into two groups: the bacteria and the archaea.



Staphylococcus aureus bacteria magnified about 10,000x



Halobacterium salinarium archaea

Bacteria

Bacteria are the most diverse and largest group of organisms on Earth. Bacteria inhabit practically all environments where some liquid water is available and the temperature is below +140°C. They are found in sea water, soil, animals' gastrointestinal tracts, hot springs and even deep beneath the Earth's surface in rocks. Practically all surfaces which have not been specially sterilized are covered in bacteria. The number of bacteria in the world is estimated to be around five million trillion trillion, or 5×10^{30}. Bacteria are practically all invisible to the naked eye, with a few extremely rare exceptions, such as *Thiomargarita namibiensis.* They are unicellular organisms and they do not have **organelles**. Bacteria are surrounded by a cell wall, which provides strength and rigidity to their cells. They reproduce asexually or sometimes by budding. Under optimal conditions bacteria can grow very rapidly, doubling its numbers every 10 minutes.

Archaea

Archaea are also single-celled organisms without nuclei. In the past, the differences between bacteria and archaea were not recognized and archaea were classified as bacteria. Archaea differ from bacteria in their genetics and biochemistry. For example, while bacterial cell membranes are made from phosphoglycerides with ester bonds, archaean membranes are made of ether lipids. Archaea were originally described to be in extreme environments, such as hot springs, but have since been found in all types of habitats. Only now are scientists beginning to appreciate how common archaea are throughout the earth environment. In fact crenarchaeota is the most common form of life in the ocean, impacting ecosystems below 150 m in depth. These organisms are also common in soil and play a vital role in ammonia oxidation.

Microorganisms - Immunization - Fermentation

Eukaryotes

All living things which are individually visible to the naked eye are eukaryotes (with few exceptions, such as Thiomargarita namibiensis). They include humans. However, a large number of eukaryotes are also microorganisms. Unlike bacteria and archaea, eukaryotes contain **organelles** such as the cell nucleus, the Golgi apparatus and mitochondria in their cells. The nucleus is an organelle which houses the DNA (unique individual genetic traits of the life form). Mitochondria are organelles vital in metabolism as they are the site of the citric acid cycle and oxidative phosphorylation. They evolved from symbiotic bacteria (bacteria living inside or in coexistence with another organism). Like bacteria cells, plant cells have cell walls, and contain organelles such as chloroplasts, produce energy from light by photosynthesis.

Unicellular eukaryotes are those eukaryotic organisms that consist of a single cell throughout their life cycle. This qualification is significant since most multicellular eukaryotes consist of a single cell called a zygote at the beginning of their life cycles. Microbial eukaryotes can be either haploid or diploid, and some organisms have multiple cell nuclei (see coenocyte). However, not all microorganisms are unicellular as some microscopic eukaryotes are made from multiple cells.

An amoeba, a typical eukaryotic microorganism

Dust Mite

Protists

Of eukaryotic groups, the protists are most commonly unicellular and microscopic. This is a diverse group of organisms which are not easy to classify. Several algae species are multicellular microbes, and slime molds have unique life cycles with unicellular, colonial, and multicellular stages.

Microscopic Animals

All animals are multicellular, but some are too small to be seen by the naked eye. Microscopic animals like arthropods include dust mites and spider mites. Microscopic crustaceans include copepods and the cladocera. Another common group of microscopic animals are the rotifers, which are filter feeders that are usually found in fresh water.

Microorganisms - Immunization – Fermentation

Microscopic Plants - The green algae are a large group of photosynthetic eukaryotes that include many microscopic organisms. Although some green algae are classified as protists, others such as charophyta are classified with embryophyte plants, which are the most familiar group of land plants.

Microscopic Fungi - The fungi kingdom has several one cell organisms, such as baker's yeast (scientific name - Saccharomyces cerevisiae).

Habitats, Ecology, and Ecosystems of Microorganisms

Microorganisms are found in almost every habitat present in nature. Even in hostile environments such as the north and south poles, deserts, geysers, rocks, and the deep sea. Some types of microorganisms have adapted to the extreme conditions and are sustained in colonies; these organisms are known as **extremophiles.** Extremophiles have been isolated from rocks as much as 7 kilometers below the earth's surface, and it has been suggested that the amount of living organisms below the earth's surface may be comparable with the amount of life on or above the earth surface. Extremophiles have been known to survive for a prolonged time in a vacuum, and can be highly resistant to radiation, which may even allow them to survive in space. Many types of microorganisms have intimate symbiotic relationships with other larger organisms; some of which are mutually beneficial **(mutualism)**, while others can be damaging to the host organism **(parasitises**). If microorganisms can cause disease in a host they are known as **pathogens (**germs**).**

Some Important Uses of Microbes

• **Soil microbes -** The nitrogen cycle in soil depends on the fixation of atmospheric nitrogen. One way this can occur is in the nodules in the roots of vegetables that contain symbiotic bacteria of the genera *Rhizobium*, *Mesorhizobium*, *Sinorhizobium*, Bradyrhizobium, and Azorhizobium. These soil microbes help produce a certain supply of nitrogen.

• **Symbiotic Microbes** – Microorganisms are vital to humans and the environment, as they participate in the Earth's element cycles such as the carbon cycle, oxygen cycle and nitrogen cycle, as well as fulfilling other vital roles in virtually all ecosystems, such as recycling other organisms' dead remains and waste products through decomposition. Microbes also have an important place in most higher-order multi-cellular organisms and symbionts (existing inside of these organisms and performing valuable functions).

• **Use in water treatment** - Microbes are used in the biological treatment of sewage and industrial waste.

• **Use in science** - Microbes are also essential tools in biotechnology, biochemistry, genetics, and molecular biology. Microbes can be guided for uses such as creating steroids and treating skin diseases. Scientists are also considering using microbes for living fuel cells, and as a solution for pollution.

Microorganisms - Immunization - Fermentation

• **Immunization** – Immunization is the process by which an individual is exposed to an agent that is designed to fortify his or her immune system against that agent. The material is known as an immunogen. Immunization is the same as inoculation and vaccination. When the human immune system is exposed to a disease once, it can develop the ability to quickly respond to future infections of the disease. Therefore, by exposing an individual to an immunogen in a controlled way, their body will then be able to protect itself from infection later on in life.

By injecting a human with the cowpox virus (which is harmless to humans), it was learned that the immunized human was then also immune to smallpox. After successful vaccination campaigns throughout the 19th and 20th centuries, the World health Organization (WHO) certified the eradication of smallpox in 1979.

Some common immunizations (vaccinations) frequently suggested or required for school children are:


Measles vaccine

DPT - (Diphtheria, Pertussis, Tetanus) – Five doses if the fourth one was before the fourth birthday.
Measles – Two doses, the first one after 12 months of age, and the second one at least 28 days after the first birthday.
Rubella – Same as measles
Mumps – Same as measles
Polio – Four doses if the third was before the fourth birthday.
Hepatitis B – For students starting Kindergarten

Each year, many persons, especially the elderly, are suggested to take the flu vaccine.

• **Active Immunization** – Active immunization is where the actual microbe is taken in by a person. Antibodies are created by the recipient and are stored permanently. Active immunization can occur naturally when an untreated microbe is received by a person who has not yet come into contact with the microbe and has no pre-made antibodies for defense. The immune system will eventually create antibodies for the microbe, but this is a slow process and, if the microbe is deadly, there may not be enough time for the antibodies to begin being used.

Artificial active immunization is where the microbe is injected into the person before they are able to take it in naturally. The microbe is treated, so that it will not arm the injected person. Depending on the type of disease, this technique also works with dead microbes, parts of the microbe, or treated toxins from the microbe.

Passive immunization is where pre-made antibodies are given to a person. This method of immunization begins to work very quickly, but it is short lasting, because the antibodies are naturally broken down, and not stored for later use. It can also result in serum sickness.

Microorganisms - Immunization - Fermentation

Listed are some diseases that are currently preventable by immunization:

Anthrax	Cervical Cancer (Human Papillomavirus)
Diphtheria	Hepatitis A
Hepatitis B	*Haemophilus influenzae* type b (Hib)
Human Papillomavirus (HPV)	Influenza (Flu)
Japanese encephalitis (JE)	Lyme disease (vaccine no longer available in USA)
Measles	Meningococcal

Monkeypox
There is NO monkeypox vaccine. The smallpox vaccine is used for this disease.

Mumps	Pertussis
Pneumococcal	Polio
Rabies	Rotavirus
Rubella	Shingles (Herpes Zoster)
Smallpox	Tetanus
Typhoid	Tuberculosis (TB)
Varicella (Chickenpox)	Yellow Fever

What is a Microscope?

A **microscope** is an instrument for viewing objects that are too small to be seen by the naked or unaided eye. Microscopes are used to detect the microbes that cause diseases.

Stereo Microscope

Electron Microscope

Optical Microscope

Microorganisms - Immunization - Fermentation

The Fungus Kingdom

The fungus kingdom is a unique group of organisms that include mold, yeasts, rusts, smuts, mildews, mushrooms, and toadstools. There are around 70,000 species of fungi identified by biologists. However, there may be as many as 1.5 million actually in existence. They are not considered to be plants for three (3) main reasons: they have no leaves or roots; they contain no chlorophyll and are therefore unable to make their own food by photosynthesis; and they reproduce by spores. Some fungi are edible but many are very poisonous; they often cause damage and sometimes disease to the organic matter on which they live and feed. Some fungi are used in the production of food and drink (for example, yeasts in baking and brewing) and in medicine (for example, penicillin).

Fungi are either parasites, existing on living plants or animals, or saprotrophs, living on dead matter. Many of the most damaging plant diseases are caused by fungi. Several fungi attack humans and animals. Athlete's foot, thrush, and ringworm are fungal diseases. Endophytes are fungi that live inside plants. Almost all plants have endophytes and many have large numbers, for example the grass fescue has 400 species of fungi. Before the classification fungi came into being, it was often studied with algae and bacteria. Two familiar fungi are bread mold and mushrooms.

The mycelium of a true fungus is made up of many intertwined hyphae. When the fungus is ready to reproduce, the hyphae become closely packed into a solid mass called the fruiting body, which is usually small and inconspicuous but can be very large. Mushrooms, toadstools, and bracket fungi are all examples of large fruiting bodies. These carry and distribute the spores. Most species of fungi reproduce both asexually (on their own) and sexually (involving male and female parents).

• **Mushrooms –** A mushroom looks like a puffball. Bunches of strands living underground are called hyphae (pronounced hi-fah). Those strands are the basic fungus in action, decomposing leaves or rotting bark on the ground. When it's time to reproduce, they develop a stalk and a cap. The mushroom that you see popping out of the ground is only part of the fungus. On the bottom of that cap are a set of gills that have little clubs with fungus spores.

Mushroom

• **Zygotes** – Mold is only one example of the Zygote Fungi. These have hyphae-like mushrooms by they reproduce in a different way. When it is tine to make more fungi, they create a stalk and release something called zygospores (thus the name zygote). When your bread gets old and green or black, you are seeing a type of zygote fungus in action. If you wait long enough, you will see the stalks develop and the zygotes released.

Microorganisms - Immunization - Fermentation

Fermentation is a process of energy production in a cell under anaerobic conditions (with no oxygen required). Fermentation may mean:

- **Fermentation (biochemistry),** the process of energy production in a cell under anaerobic conditions (in a lack of oxygen),
- **Ethanol fermentation**, a form of anaerobic respiration used primarily by yeasts when oxygen is not present in sufficient quantity for normal cellular respiration,
- **Industrial fermentation**, the breakdown and re-assembly of biochemicals for industry, often in aerobic growth conditions

In *Food science*, fermentation may mean:

- **Fermentation (food),** the conversion of carbohydrates into alcohols or acids under anaerobic conditions used for making certain foods,
- **Fermentation (wine),** the process of fermentation commonly used in winemaking.
- **Brewing**, the process of fermentation as used in making beer.
- **Fermentation (tea),** the name used in the tea industry for the aerobic treatment of tea leaves to break down certain unwanted chemicals and modify others to develop the flavor of the tea.

• **Human digestion** - Microorganisms can form an endosymbiotic relationship with other, larger organisms. For example, the bacteria that live within the human digestive system contribute to gut immunity, synthesize vitamins such as folic acid and biotin, and ferment complex indigestible carbohydrates**.**

• **Use in food -** Microorganisms are used in brewing, baking and other food-making processes. Microorganisms are also used to control the fermentation process in the production of cultured dairy products such as yogurt and cheese. The cultures also provide flavor and aroma, and to inhibit undesirable organisms.

Bread

Fermentation in **food processing** typically refers to the conversion of sugar to alcohol using yeast under anaerobic conditions. A more general definition of fermentation is the chemical conversion of carbohydrates into alcohols or acids. When fermentation stops prior to complete conversion of sugar to alcohol, a stuck fermentation is said to have occurred. The science of fermentation is known as **zymology**. Fermentation usually implies that the action of the microorganisms is desirable, and the process is used to produce alcoholic beverages such as wine, beer, and cider. Fermentation is also employed in preservation to create lactic acid in sour foods such as pickled cucumbers, kimchi and yogurt.

Microorganisms - Immunization – Fermentation

The process of *fermentation in wine* is the catalyst function that turns grape juice into an alcoholic beverage. During fermentation yeast interact with sugars in the juice to create ethanol, commonly known as ethyl alcohol, and carbon dioxide (as a by-product). In winemaking the temperature and speed of fermentation is an important consideration as well as the levels of oxygen present in the must at the start of the fermentation. The risk of stuck fermentation and the development of several wine faults can also occur during this stage which can last anywhere from 5 to 14 days for primary fermentation and potentially another 5 to 10 days for a secondary fermentation. Fermentation may be done in stainless steel tanks, which is common with many white wines like Riesling, in an open wooden vat, inside a wine barrel and inside the wine bottle itself like in the production of many sparkling wines.

. • **Single Cell Fungi –** Sac Fungi are simple, single celled fungi. Yeast is used to make several types of food for humans. We need yeast to make breads. We also use them to make alcohol. It is a whole process called fermentation. Sugars are broken down in an environment without oxygen. It is called anaerobic fermentation. And viola, alcohol. Even tough they are single-celled; you may find them living in colonies. They reproduce very quickly and hangout together. It takes a lot of them (because they are so small) to get a lot of work done.

• **Mold** – There are no such thing as molds. All molds are actually fungi. That is a bunch fungus. Many know about mold in the shower or mold on the bread. Molds are actually a type of fungus. It has a shape called a zygote to be exact. While yeasts are ingle celled fungi, molds are multi-cellular fungi. Bread takes one kind of fungus (yeast) to make it rise. If you leave the bread out, another type of fungus comes in (bread mold) to break it down. Fungi help to build and destroy.

Photograph of a **mold** culture dish

• **Use in energy -** Microbes are used in fermentation to produce ethanol a fuel for cars.

Microorganisms - Immunization – Fermentation

Activity 1

1. What is a microbe?
2. What is the name of the science and the scientist who studies microbes?
3. Which of the five kingdoms that contain microorganisms?
4. Which kingdom has the largest number of microorganisms?
5. What are the names we use when we classify living things in domains?
6. What is a unicellular organism?
7. How do microbes reproduce?
8. What are prokaryotes; what two large groups of organisms are prokaryotes; compare and contrast these groups.
9. What is the difference between autotrophic and heterotrophic microorganisms?
10. What is an organelle; give some specific examples of organelles.
11. What is the difference between good microbes and bad microbes; give examples.
12. Compare and contrast prokaryotes and eukaryotes; give some examples of each.
13. Describe and discuss some intimate symbiotic relationships that some microbes have with other larger organisms; some that are beneficial (mutulism) to the larger organisms and some that are damaging or harmful (parasitic) to the larger organisms.
14. Name some specific diseases caused by some specific microbes and viruses.
15. Discuss how immunization and practices of good hygiene habits can help one to stay healthy.

Part II: Life Science

Lesson 10: Infectious and Communicable Diseases

Do You Know?

An **infectious disease** is a clinically evident disease resulting from the presence of pathogenic microbial agents, including viruses, bacteria, fungi, protozoa, multicellular parasites, and aberrant proteins known as prions. A **pathogen** or **infectious agent** is a biological agent that causes disease or illness to its host. The term is most often used for agents that disrupt the normal physiology of a multicellular animal or plant. Infectious pathologies are usually qualified as **communicable diseases** (also called **contagious diseases**) due to their likelihood of transmission from one person or species to another. Transmission of an infectious disease may occur through one or more of diverse pathways including physical contact with infected individuals. These infecting agents may also be transmitted through liquids, food, body fluids, contaminated objects, airborne inhalation, or through vector-borne spread.

The term **infectivity** describes the ability of an organism to enter, survive and multiply in the host, while the infectiousness of a disease indicates the comparative ease with which the disease is transmitted to other hosts. An infection however, is not synonymous with an infectious disease, as an infection may not cause important clinical symptoms or impair host function.

In this lesson one can learn many things about infectious and communicable diseases. Such diseases include, malaria, HIV – AIDS and many others; including cholera, tuberclosis

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Infectious and Communicable Diseases

Classification

Among the almost infinite varieties of microorganisms, relatively few cause disease in otherwise healthy individuals. Infectious disease results from the interplay between those few pathogens and the defenses of the hosts they infect. The appearance and severity of disease resulting from any pathogen depends upon the ability of that pathogen to damage the host as well as the ability of the host to resist the pathogen. Infectious microorganisms, or microbes, are therefore classified as either primary pathogens or as opportunistic pathogens according to the status of host defenses.

Primary pathogens cause disease as a result of their presence or activity within the normal, healthy host, and their intrinsic virulence (the severity of the disease they cause) is, in part, a necessary consequence of their need to reproduce and spread. Many of the most common primary pathogens of humans only infect humans; however many serious diseases are caused by organisms acquired from the environment or which infect non-human hosts. Organisms which cause an infectious disease in a host with depressed resistance are classified as opportunistic pathogens. Opportunistic disease may be caused by microbes that are ordinarily in contact with the host, such as bacteria or fungi in the gastrointestinal or the upper respiratory tract, and they may also result from (otherwise innocuous) microbes acquired from other hosts or from the environment as a result of traumatic introduction (as in surgical wound infections or compound fractures). An opportunistic disease requires impairment of host defenses, which may occur as a result of genetic defects.

Epidemiology is another important tool used to study disease in a population. For infectious diseases it helps to determine if a disease outbreak is sporadic (occasional occurrence), endemic (regular cases often occurring in a region), epidemic (an unusually high number of cases in a region), or pandemic (a global epidemic).

Transmission - An infectious disease is transmitted from some source. Defining the means of transmission plays an important part in understanding the biology of an infectious agent, and in addressing the disease it causes. Transmission may occur through several different mechanisms. Respiratory diseases and meningitis are commonly acquired by contact with aerosolized droplets, spread by sneezing, coughing, talking or even singing. Gastrointestinal diseases are often acquired by ingesting contaminated food and water. Sexually transmitted diseases are acquired through contact with bodily fluids, generally as a result of sexual activity. Some infectious agents may be spread as a result of contact with a contaminated, inanimate object (known as a fomite), such as a coin passed from one person to another, while other diseases penetrate the skin directly.Transmission of infectious diseases may also involve a "vector". Vectors may be mechanical or biological. A mechanical vector picks up an infectious agent on the outside of its body and transmits it in a passive manner. An example of a mechanical vector is a housefly, which lands on cow dung, contaminating its appendages with bacteria from the feces, and then lands on food prior to consumption. The pathogen never enters the body of the fly.

Infectious and Communicable Diseases

Mosquitos (*Culex quinquefasciatus*) are biological vectors that transmit West Nile Virus.

In contrast, biological vectors harbor pathogens within their bodies and deliver pathogens to new hosts in an active manner, usually a bite. Biological vectors are often responsible for serious blood-related diseases, such as **malaria**, **viral encephalitis** (inflammation of the brain), and **African sleeping sickness**. Biological vectors are usually, though not exclusively, animals such as flies, mosquitoes, ticks, fleas and lice. Vectors are often required in the life cycle of a pathogen. A common strategy, used to control vector related infectious diseases, is to interrupt the life cycle of a pathogen, by killing the vector.

Diagnosis and therapy

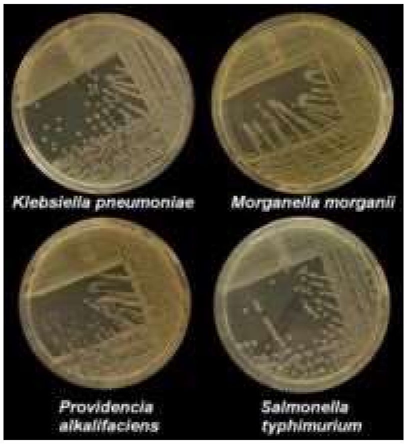
Diagnosis of infectious disease sometimes involves identifying an infectious agent either directly or indirectly. In practice most minor infectious diseases such as warts, cutaneous abscesses, respiratory system infections and diarrheal diseases are diagnosed by their clinical presentation. Conclusions about the cause of the disease are based upon the likelihood that a patient came in contact with a particular agent, the presence of a microbe in a community, and other epidemiological considerations. Given sufficient effort, all known infectious agents can be specifically identified. The benefits of identification, however, are often greatly outweighed by the cost, as often there is no specific treatment, the cause is obvious, or the outcome of an infection is benign.

Methods of diagnosis

Diagnosis of infectious disease is nearly always initiated by medical history and physical examination. Other techniques (such as X-rays, CAT scans, PET scans or NMR) are used to produce images of internal abnormalities resulting from the growth of an infectious agent.

Infectious and Communicable Diseases

Microbial culture

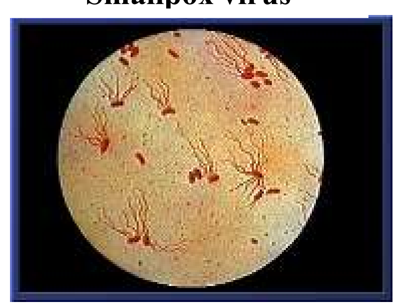


Four nutrient agar plates growing colonies of common Gram negative bacteria.

Microbiological culture is a principal tool used to diagnose infectious disease. In a microbial culture, a growth medium is provided for a specific agent. A sample taken from potentially diseased tissue or fluid is then tested for the presence of an infectious agent able to grow within that medium.

A Carrier of Typhoid

Smallpox virus



Mary Mallon was an asymptomatic carrier of typhoid fever. Over the course of her career as a cook, she infected 53 people, three of whom died.

Infection with most pathogens does not result in death of the host; however some do if they are not properly treated.

Infectious and Communicable Diseases

Mortality from infectious diseases

The World Health Organization (WHO) collects information on global deaths by International Classification of Disease (ICD) code categories. The following table lists the top infectious disease killers which caused more than 100,000 deaths in 2002 (estimated). 1993 data is included for comparison.

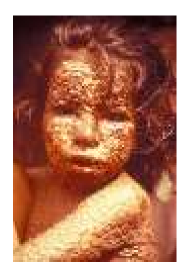
Worldwide mortality due to infectious diseases[6]

Rank	Cause of death	Deaths 2002	Percentage of all deaths	Deaths 1993	1993 Rank
N/A	All infectious diseases	14.7 million	25.9%	16.4 million	32.2%
1	Lower respiratory infections	3.9 million	6.9%	4.1 million	1
2	HIV/AIDS	2.8 million	4.9%	0.7 million	7
3	Diarrheal diseases	1.8 million	3.2%	3.0 million	2
4	Tuberculosis (TB)	1.6 million	2.7%	2.7 million	3
5	Malaria	1.3 million	2.2%	2.0 million	4
6	Measles	0.6 million	1.1%	1.1 million	5
7	Pertussis	0.29 million	0.5%	0.36 million	7
8	Tetanus	0.21 million	0.4%	0.15 million	12
9	Meningitis	0.17 million	0.3%	0.25 million	8
10	Syphilis	0.16 million	0.3%	0.19 million	11
11	Hepatitis B	0.10 million	0.2%	0.93 million	6
12-17	Tropical diseases (6)	0.13 million	0.2%	0.53 million	9, 10, 16-18

Note: Other causes of death include maternal and perinatal conditions (5.2%), nutritional deficiencies (0.9%), noncommunicable conditions (58.8%), and injuries (9.1%).

The top three single agent/disease killers are HIV/AIDS, TB and malaria. While the number of deaths due to nearly every disease have decreased, deaths due to HIV/AIDS have increased fourfold. Childhood diseases include pertussis, poliomyelitis, diphtheria, measles and tetanus. Children also make up a large percentage of lower respiratory and diarrheal deaths.

Historic pandemics



A young Bangladeshi girl infected with smallpox (1973). Thanks to the development of the smallpox vaccine, the disease was officially eradicated in 1979.

Infectious and Communicable Diseases

A pandemic (or global epidemic) is a disease that affects people over an extensive geographical area. Some examples:

- Smallpox killed an estimated 60 million Europeans in the 18th century alone. Up to 30% percent of those infected, including 80% of the children under 5 years of age, died from the disease, and one third of the survivors went blind.
- The Influenza Pandemic of 1918 (or the Spanish Flu) killed 25-50 million people (about 2% of world population of 1.7 billion).
- Today Influenza kills about 250,000 to 500,000 worldwide each year.

Emerging diseases and pandemics

In most cases, microorganisms live in harmony with their hosts. Such is the case for many tropical viruses and the insects, monkeys, or other animals in which they have lived and reproduced. Because the microbes and their hosts have co-evolved, the hosts gradually become resistant to the microorganisms.

Medical specialists

The medical treatment of infectious diseases falls into the medical field of **Infectiology** and in some cases the study of propagation pertains to the field of Epidemiology. Generally, infections are initially diagnosed by primary care physicians or internal medicine specialists. For example, an "uncomplicated" pneumonia will generally be treated by the internist or the pulmonologist (lung physician).

An infectious disease team may be alerted when:

The disease has not been definitively diagnosed after an initial workup
The patient is immunocompromised (for example, in AIDS or after chemotherapy);
The infectious agent is of an uncommon nature (e.g. tropical diseases);
The disease has not responded to first line antibiotics;

The disease might be dangerous to other patients, and the patient might have to be isolated.

Infectious and Communicable Diseases

Hygiene - Hygiene is the avoidance of infection or food spoiling by eliminating microorganisms from the surroundings. In that microbes, particularly bacteria, are found practically everywhere, this means in most cases the reduction of harmful microbes to acceptable levels. However, in some cases it is required that an object or substance is completely sterile, i.e. completely clear of all living entities and viruses. A good example of this is a hypodermic needle. In the preparation of food, the presence of microbes is reduced by preservation methods (such as the addition of vinegar), use of clean utensils, short storage periods or by hot or cool temperatures. If complete sterility is needed, the two most common methods are irradiation and the use of an autoclave, which resembles a pressure cooker.

There are several methods for checking the level of hygiene in a sample of food, drinking water, equipment etc. Water samples can be filtrated through an extremely fine filter. This filter is then placed in a nutrient medium. Microorganisms on the filter then grow to form a visible colony. Harmful microorganisms can be detected in food by placing a sample in a nutrient broth designed to enrich the organisms in question. Various methods can then be used to detect what microbes are present. The level of sterility of hard surfaces, such as cooking pots, can be tested by touching them with a solid piece of nutrient medium and then allowing the microorganisms to grow on it, later detecting what microbes are present. There are no conditions where all microbes can grow. Thus, different methods are needed to test for different kinds of microbes and therefore often several different methods are needed. For example, a food sample might be analyzed on three different nutrient mediums designed to indicate the presence of "total" bacteria (conditions where many, but not all, bacteria grow), molds (conditions where the growth of bacteria is prevented by e.g. antibiotics) and coliform bacteria (these indicate a sewage contamination).

The best defense against infectious diseases is the practice of good health habits and the practice of good hygiene.

Part III Earth Science

Part III: Earth Science

Lesson 1: Earth's Physical Surface and its Geography

Do You Know?

Earth science is the study of the plant Earth and things that greatly influence the Earth's physical structure. Earth's surface consists of a very thin layer of rocks. This rocky surface of the Earth is called the **lithosphere**. Above Earth's surface is a mixture of gases that make up the air that organism breath. This air surrounding Earth is called the **atmosphere.** The water covering the surface of the Earth is called Earth's **hydrosphere**. The hydrosphere includes all liquid water in the ground, and water vapor in the atmosphere.

Planet Earth is shaped like a **sphere**, a round ball. Earth is not perfectly round, it has bulges a little at the equator, and in certain mountainous ranges. Based on observations, careful experiments, a number of other things, from the surface of the Earth to the center of the Earth is about 6,380 kilometers. If it were possible for one to take this journey one would pass through Earth's four (4) main layers, each layer has a different thickness and a different temperature.

In this lesson we study more details about Earth's physical structure, especially in the lithosphere and hydrosphere of the surface of planet Earth.

Earth's Physical Surface and its Geography

Activity 1

1. What is an organism?
2. What is a cell?
3. What are the six (6) characteristics that all living things exhibit?
4. What are two names we use to describe the study of living things?
5. What is the name that we use to classify living things in five (5) large distinct groups?
6. Name one or two characteristics that distinguish **animals** from members of other kingdoms.
7. Name one or two characteristics that distinguish **plants** from members of other kingdoms..
8. Name one or two characteristics that distinguish **fungi** from members of other kingdoms.
9. Name one or two characteristics that distinguish **protists** from members of other kingdoms
10. Name one or two characteristics that distinguish **bacteria** from members of other kingdoms.
11. Name a specific **animal**; draw a picture of the **animal**; describe the animal to the class; and discuss how the **animal** exhibits some of its basic life functions.
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Part III: Earth Science

Lesson 2: Earth's Changing Surface and it's Geography

Do You Know?

The surface of planet Earth is **dynamic**; that is it constantly changing. Glaciers, erosions caused by wind, waves, running water and gravity are other entities that greatly impact the Earth's surface.

These and other entities like mining and the weather greatly impact the Earth surface. The Nature of the Earth's surface is constantly undergoing many changes. In this lesson we consider the impact of these entities as well as plants and animals use (and misuse) o f the planets resources. These things cause the **surface** of planet Earth to undergo slow changes.

Earth's Changing Surface and its Geography

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Part III: Earth Science

Lesson 3: Earth's Central Core, Interior Activities, and Natural Resources

Do You Know?

In this lesson on learns many details about the four (4) layers of the Earth if one were to make a journey to the center of the Earth. The lesion also discusses, earthquakes, volcano eruptions, geysers and other phenomenon caused by dynamics that occur in the interior of the Earth.

Earth's Central Core, Interior Activities, and Natural Resources

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Part III: Earth Science

Lesson 4: Earth's Soil and Minerals: Proper Use and Conservation

Do You Know?

Every farmer knows that certain crops grow in certain types of soil. Farmers learn how to take good care of soil to make it useful for growing crops year after year. Without useful soil, farmers could not produce food and other crops year after year. Soil begins to form when bedrock is broken apart into small pieces of rocks and minerals. This decomposition of bedrock can occur because of rain, ice, wind, freezing and thawing. Chemical changes can break down bedrock. Plants and animals that live in small pieces of bedrock help to break them down further. Soil takes a long time to form. It may take hundreds of thousands of years to form one inch of soil. There are dozens of different kind of soils, each with its own set of properties. The properties include texture, composition and thickness, mineral context and the place where it formed.

In this lesson on studies a variety of soil, its formation and its use by farmers and others.

If on looks closely at a rock, one might see tiny grains that have different colors. Each grain or crystal is a mineral. A **crystal** is a solid material found in nature that has straight edges and flat sides. A **rock** is a mixture of minerals and other hard surfaces. Scientists classify rocks according to how they form.

According to many scientists, organisms have lived on planet Earth for at least 3.5 billion years. Over time organisms and the environment has changed many times. Fossils hold the clues to learning about those changes. **Fossils** are the remains or traces of organisms that lived long ago. Most fossils are found in sedimentary rock. The original organisms were trapped in sediments. Sediment is a material that settles to the bottom of a liquid. Solid fragments of inorganic or organic material that come from the weathering of rock and are carried and deposited by wind, water, or ice.

When the sediment harden into rock, the images of the organisms remain in the rock. In this lesson one learns about Earths important minerals, rocks and fossils.

Earth's Soil and Minerals: Proper Use and Conservation

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.Part III: Earth Science

Lesson 5: Earth's Seasons, Climate, and Weather

Do You Know?

A **revolution** is a complete trip around the sun. One revolution equals on year. Earth makes on e revolution in 365 ¼ days. But your calendar shows that most years are only 365 days long. The missing quarters of a day add up year after year. In four years, one whole day has been added. The "extra" day is shown on the calendar as February 29. That year has 366 days and is called a leap year. Earth's path around the sun is called its **orbit**. Earths orbit is not a circle. It is a shape called an ellipse. Think of an ellipse as a flattened circle that is longer than it is wide.

Earth is tilted 23 ½ degrees on its axis. Because of this tilt, different parts of Earth have different amounts of daylight and darkness at the same time of the year. And sunlight strikes different parts of earth more directly in some places and at a lower angle in other places. These differences cause Earth's **seasons**. In temperate climates, there are four seasons: winter, spring, summer, and autumn; in tropical climates, there are two seasons: the rainy season and the dry season; and in Polar climates, it is mostly cold.

Climate is the general weather of an area over a long period of time, such as many years. A region's climate is affected by many things. These include the region's latitude, longitude, and elevation, nearness to large bodies of water and nearby ocean currents. Scientists have identified three basic climates on Earth: tropical, temperate, and polar.

Weather is the conditions of the atmosphere over a certain part of Earth at a certain time. Weather can change from season to season, month to month, week to week, day to day, hour to hour, or even minute to minute. There are many different conditions in the atmosphere that affect weather such as temperature, wind, air pressure, humidity, precipitation, cloud formation, weather fronts, global winds, jet streams, and severe weather conditions like thunderstorms, tornadoes, hurricanes, blizzards, cyclones, etc. On the other hand, there are now many weather models with which scientists can predict the weather ahead of time in a specific place over periods of time – as long as a full week, with a fair degree of accuracy.

In this lesson one can learns some of the major impacts of seasons, climate and weather on a region and on the organisms that exist in that region as well on the surface of the Earth in that region.

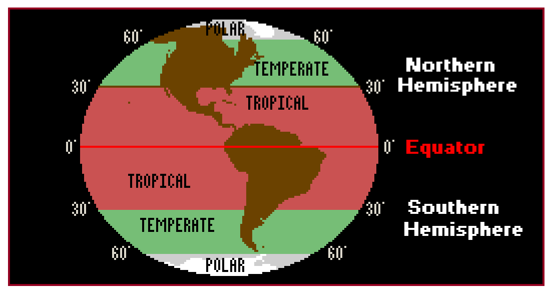
Earth’s Seasons, Climate, and Weather

Seasons

In temperate climates, one can note that summer is when the Northern Hemisphere is warmest. In July, August, and September, sunlight strikes the Northern Hemisphere more directly and for more hours each day than it does in January, February, and March. So the Northern Hemisphere has summer from July until September. Seasons are opposite in the Northern Hemisphere and the Southern Hemisphere. The first day of summer in the Northern Hemisphere happens when the Northern Hemisphere is most tilted toward the sun. At that same time, the first day of winter comes to the Southern Hemisphere. On this day, the Southern Hemisphere is most tilted away from the sun.

When it is fall in North America, it is spring in South America. When it is spring in North America, it is fall in South America. On the first day of fall and spring, Earth isn’t tilted either away from or toward the sun. Day and night are about equal in length.

World Climate Zones



Climate

Scientists identify three basic climates on Earth. The climates are tropical, temperate, and polar.

- Polar climates – cold and dry; they are located in bands around the North and South Poles.
- Tropical climates – warm; they can be wet, dry, or somewhere in between. They are found in a wide band around the Earth’s equator.
- Temperate climates – moderate temperatures that change with the seasons; precipitation varies from place to place and from season to season. Temperate climates are found in bands between the polar and tropical climates

Earth’s tilt on its axis is mainly responsible for these climate bands. For example, in December the North Pole is tilted away form the sun. Sunlight doesn’t reach the North Pole, and temperatures plunge. Even in June, sunlight is at a low angle and does not heat the land much. So this region stays cold all year round. Sunlight hits the temperate regions more directly in summer and less directly in winter. So these regions become warmer and cooler and warmer again as the seasons pass. The tropical regions get the most direct sunlight all year. So they are warm all year. A region’s climate is affected by many things. These include the region’s latitude, elevation, nearness to large bodies of water, and nearby ocean currents.

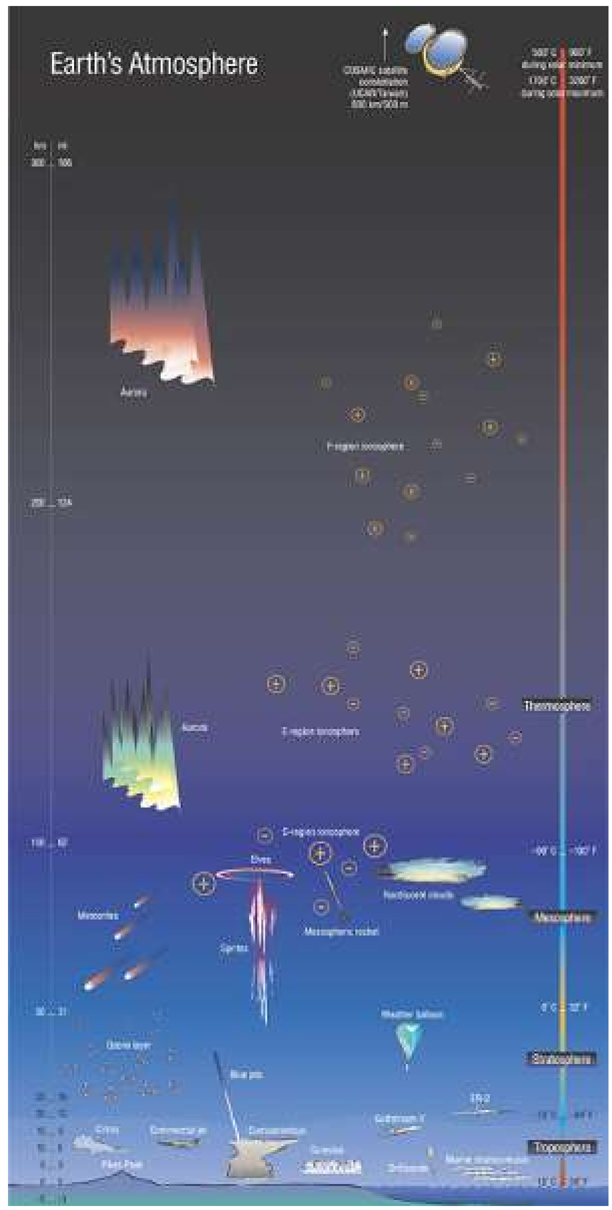
Earth's Seasons, Climate, and Weather

Layers of the Atmosphere

Earth's atmosphere has five layers. Each layer has different properties, such as temperature and air pressure. Air pressure is the push of air against objects in all directions. As air heats and cools, it moves into and out of different layers.

Exosphere – (300 km to more than 600 km)

- Many satellites orbit here.
- Air pressure is lowest here.
- Temperature goes up as altitude increases.



Thermosphere – (90 km to 300 km)

- Shimmering curtains of light called *auroras* happen here.
- Air pressure is lower than mesosphere.
- Temperature goes up as altitude increases.

Mesosphere – (50 km to 90 km)

- Meteors, or "shooting stars," burn up here.
- Air pressure is lower than stratosphere.
- Temperature goes down as altitude increases. This is the coldest layer of the atmosphere.

Stratosphere – (16 km to 50 km)

- Jets cruise near the bottom of this layer.
- Air pressure is lower than troposphere.
- Temperature goes up as altitude increases.

Troposphere – (0 km to 16 km)

- All weather happens here.
- Air pressure is highest in this layer.
- Temperature goes down as altitude increases.

Earth’s Seasons, Climate, and Weather

Temperature

The land and water on Earth’s surface absorb heart energy from the sun. Some of this heart energy then warms the atmosphere above the surface. The amount of heat that is absorbed by Earth’s surface and then released in to the atmosphere changes from hour to hour and day to day.

The sun is lowest in the sky early in the morning. When the sun is low in the sky, sunlight strikes Earth’s surface at a low angle. The sunlight is spread our so the ground warms up less. At noontime, when the sun is highest in the sky, sunlight strikes the Earth’s surface like a more focused beam. The light is more concentrated. Earth’s surface heats up more. A few hours later, much of this heat has warmed the atmosphere. That’s why temperatures are highest in mid-afternoon.

Away from the equator, temperatures in the summer are warmer than temperatures in th winter. This difference is also caused by the position of the sun in the sky. In summer, the sun rises higher in to the sky than it does in winter. So the sun’s rays are more concentrated on Earth’s surface on a summer day than on a winter day.

Different surfaces heat up at different rates. Grass heats up very slowly and does not hold heat well. That’s why grass feels cold to your bare feet on a hot day. Water heats up slowly but holds heat longer than grass. Roads, especially black tar roads, heat up quickly and can get very hot on a summer day. They cool down quickly during the night.

Wind

Wind is moving. Air moves because Earth’s surface is heated unevenly. On a hot summer day at the beach, the land heats up faster than the water. The air above the land becomes warmer than the air above the water. The warmer air above the land rises. It is replaced by cooler air moving in from above the water. This wind is called a **sea breeze**.

After sunset, the land cools faster than the water. Now the air above the water is warmer than the air above the land. The warm air above the water rises. It is replaced by cooler air moving in from above the land. This wind is called a **land breeze.**

Air Pressure

Air has mass. Because it has mass, it has weight. Air pressure is the weight of air pressing on everything around it. Air presses on objects from all sides, not just down on them. Air pressure is measured with a **barometer.** There are two main types of barometers. One is a liquid barometer and the other is an aneroid barometer.

Earth's Seasons, Climate, and Weather

Air pressure can change a s time passes. Three conditions affect air pressure:

- Water vapor – makes air moist. Air that is moister has lower air pressure. Air that is drier ahs higher air pressure.
- Temperature – When air gets warmer, its pressure goes down. When air gets cooler, its pressure goes up.
- Altitude – Air at high altitudes is thinner than air at low altitudes. "Thinner" means that the air molecules are more spread out. As altitude gets higher, air pressure goes down.

When the air pressure changes, you can tell that the weather will change. Riding air pressure means clearer weather is coming. Falling air pressure means unsettled or wet weather is coming.

Humidity

On a very humid day, your skin may feel damp. That's because the air holds a lot of water vapor. Water vapor in the air is called humidity.

Precipitation

The atmosphere contains water vapor. When the air gets cooler, water vapor condenses. That means it changes to tiny droplets of liquid water. Water droplets clump together to form a cloud. As more water vapor condenses, the droplets grow larger. When the drops get too large and heavy, they fall to Earth's surface. Water that falls to Earth's surface is called **precipitation.** There are different types of precipitation.

<u>Types of Precipitation:</u>

Drizzle	Liquid drops about 1 mm in diameter
Rain	Liquid drops about 1 mm to 3 mm in diameter
Snow	Ice in the form of six-sided crystals
Hail	Chunks or balls of ice from 5 mm to 75 mm in diameter
Sleet	Pellets of ice no more than 5 mm in diameter

Clouds

A cloud forms when water vapor in the atmosphere condenses and changes to tiny droplets of liquid water. The droplets clump together to form a cloud. If the air is cold enough, the droplets freeze to form ice crystals. Scientists use a few basic words to describe the shapes of clouds. When you observe clouds, you can use these terms to identify what kind of cloud you are seeing.

- Cirrus – means "feathery" or "tufted."
- Stratus – means "sheets" or "layers."
- Cumulus – means "piled up."

Other words tell what the cloud may produce. For example, **nimbus** means "rain cloud." So a cumulonimbus cloud is a piled up rain cloud. A nimbostratus cloud is a layered or flat rain cloud. The word part *alto-* means "middle height." So an altostratus cloud is a layered cloud at the middle height in the atmosphere. Clouds are classified by their shape and their height above the ground.

- Cirrus clouds are high, feathery clouds at 6,000 meters to 12,000 meters above Earth's surface. These clouds are made of ice crystals. Cirrus clouds may be followed by rain or snow in a few hours.

- Cumulonimbus clouds are huge vertical clouds. They stretch from 2,000 meters to 6,000 meters above Earth's surface. These clouds produce thunderstorms, so they are called "thunderheads."

- Cumulus clouds are puffy and white with flat bottoms. They are usually found between 2,000 meters and 6,000 meters above the Earth's surface. These are "fair-weather" clouds.

- Nimbostratus clouds area low, gray rain clouds or snow clouds. They are found at the same height as stratus clouds.

- Stratus clouds are flat, gray, layered clouds that cover the whole sky. They usually are less than 2,000 meters above the Earth's surface. They can bring light rain and drizzle.

- Fog is a stratus cloud that forms close to the ground. The cloud is made of very small water droplets.

Weather Systems

A weather system is an area in the lower atmosphere where the air is moving around a high or low. A high-pressure system has a high at the center. A low-pressure system has a low at the center. A weather system covers a large area. Low-pressure systems often include weather fronts. A front is where one air mass meets and pushes aside another air mass. An air mass is a large bubble of air that has about the same characteristics all through it. An air mass has the same weather from end to end and top to bottom. The main characteristics of an air mass are its temperature and humidity. An air mass can be cold and dry, warm and dry, cold and moist, or warm and moist.

Weather Fronts

There are different kinds of fronts. The leading edge of a moving mass of cooler air is a cold front. The leading edge of a moving mass of warmer air is a warm front.

Earth's Seasons, Climate, and Weather

Highs and Lows

In a high-pressure center, air pressure is higher than in the surrounding air. In a low-pressure center, air pressure is lower than in the surrounding air. Fair weather is usually found in areas where air pressure is high. Clouds and precipitation are usually found in areas where air pressure is low. Winds tend to blow from high-pressure areas to low-pressure areas. The greater the difference between the two areas' air pressure, the stronger the winds.

Jet Stream

A steady worldwide wind called the jet stream blows from west to east. This wind is 6,000 to 12,000 meters above Earth's surface. Its speed is usually about 250 kilometers per hour. And it is 160 to 400 kilometers wide.

Thunderstorms

When a cold front moves in to a warm, moist air mass, the cold air slides under the warm air. This builds up electrical charges. The charges are released in lightning. The heat of the lightning makes the air around it expand explosively. Lightning is the main danger in a thunderstorm. Follow these tips to stay safe if a thunderstorm strikes:

- Find shelter in a building or a car
- Don't go under a tree to find shelter
- If you are swimming, get out of the water. If you are in a small boat, get off.
- Do not stand in an open field. Crouch.
- If you are on a bike, get off.

Tornadoes

A tornado is a dark funnel of strong winds that spiral upward. Tornadoes are very powerful. Tornadoes are very powerful. A tornado's winds can reach speeds of 500kilometers per hour. The main danger from a tornado is the powerful winds. Follow these tips to stay safe if a tornado strikes.

- Find shelter in a basement or a tornado celler.
- Stay clear of outside walls, windows, and doors.
- Get away from cars, mobile homes, and other objects that might be flipped over or thrown by winds.
- If outdoors, find shelter in a ditch, ravine, or cave. Cover your head with your arms.

Tornado on beach shore

Earth's Seasons, Climate, and Weather

Hurricanes

Hurricanes are very large and violent tropical storms. They can be hundreds of kilometers wide. To be called a hurricane, the winds of a tropical storm must be greater than 117 kilometers per hour. Hurricanes start as small thunderstorms over warm water. Hurricanes usually form in late summer when the sun heats huge masses of moist air. The calm center of a hurricane is called the eye. High clouds move clockwise around the eye. The major dangers from a hurricane are high winds, flooding, and pounding waves. Follow these tips to stay safe if a hurricane is coming.

- Leave areas that are in the path of a hurricane well before it strikes.
- If you are caught in a hurricane, find shelter in a strong brick or stone building on high ground.
- Stay away form windows and doors.
- Keep extra food and water, a flashlight, a battery-operated radio, and, if possible, a cell phone with you.

Blizzards

A blizzard is a snowstorm with winds greater than 56 kilometers per hour and air temperature below -7°C at ground level. Blizzards usually include heavy snowfall.

Aftermath of a Blizzard

Hurricane Opal, 1995

Earth's Seasons, Climate, and Weather

Activity 1

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Part III: Earth Science

Lesson 6: How Earth Recycles Water

Do You Know?

The movement of water around, over, and through the Earth is called the **Earth's** water**, (**sometimes called the **hydrologic cycle)**. The Earth's water is always in continuous movement on Earth, above Earth, and below the surface of the Earth. Since the water cycle is truly a "cycle," there is no beginning or end. At different stages of the cycle and at different places on Earth one can find water in different states or changing states among the states: vapor (gas), liquid, and ice (solid). During the water cycle, these processes often happen very rapidly and over millions of years. Although the total volume of Earth's water remains fairly constant over time, individual water molecules do appear to change often.

The sun, which drives the water cycle, we may start by noting that the Sun heats water in the oceans. Some of it evaporates [**evaporation** is the process by which molecules in a liquid state (e.g. water) spontaneously become gaseous (e.g. water vapor)] as water vapors in the air Evaporation is the opposite of condensation [**condensation** is the change of a substance to a denser phase, such as a gas (or vapor) to a liquid]. Ice and snow can sublimate. **Sublimation** of an element or compound is a transition from the solid to gas phase with no intermediate liquid stage] directly into water vapor. Rising air currents take the vapor up into the atmosphere, along with water which transpires from plants and evaporates from the soil. The water vapor rises into the air where cooler temperatures cause it to condense into clouds. Air currents move clouds around planet earth; cloud particles collide, grow, and fall out of the sky as precipitation. Some precipitation falls as snow and can accumulate as ice caps and glaciers, which can store frozen water for thousands of years. Snow that falls in warmer climates often melts to water. When the temperature rises and the water flows over land. Most precipitation falls back into the oceans or onto land, where, due to gravity, the precipitation flows over the ground as water. A portion of the water enters rivers and streams that move the water towards the oceans. Some of the precipitation accumulates and are stored as freshwater in lakes. Much of the precipitation soaks into the ground. Some water infiltrates deep into the ground and replenishes saturated sub-surface rocks. These rocks store huge amounts of freshwater for long periods of time. Some stored ground water stays close to the land surface and can seep back into the streams, rivers, lakes and the oceans. Some ground water finds openings in the land surface and becomes freshwater springs. Over time the water continues to flow; some reenters the ocean, where the water cycle renews itself.

In this lesson, one can learn the importance of water to the existence of life on Earth.

How Earth Recycles Water

Let us first consider some important vocabulary that is frequently used in discussions of Earth's water cycle:

- **Precipitation** is condensed water vapor that falls to the Earth's surface. Most precipitation occur as **rain** (liquid water), other forms of participation occurs as **snow** (crystalline water ice – snow flakes), hail (balls or irregular lumps of ice), **fog** (a cloud in contact with the ground), **snow pellets (**snow that has formed as ice ball rather than flakes) and sleet (precipitation that is intermediate between rain and snow but distinct from hail stones). Approximately 505,000 km^3 of water fall as precipitation each year, 398,000 km^3 of it over the oceans.
- **Canopy interception** is the precipitation that is intercepted by plant foliage and eventually evaporates back to the atmosphere rather than falling to the ground.
- **Snowmelt** refers to the runoff produced by melting snow.
- **Runoff** includes the variety of ways by which water moves across the land. This includes both surface runoff and channel runoff. As it flows, the water may infiltrate into the ground, evaporate into the air, become stored in lakes or reservoirs, or be extracted for agricultural or other human uses.
- **Infiltration** is the flow of water from the ground surface into the ground. Once infiltrated, the water becomes soil moisture or groundwater.
- **Subsurface Flow** is the flow of water underground. Subsurface water may return to the surface (eg. as a spring or by being pumped) or eventually seep into the oceans. Groundwater tends to move slowly, and is replenished slowly, so it can remain below the earth for thousands of years.
- **Evaporation** is the transformation of water from a liquid phase to a gas phases as it moves from the ground or bodies of water into the atmosphere.
- **Sublimation** is the change directly from solid water (snow or ice) to water vapor.
- **Advection** is the movement of water — in solid, liquid, or vapor states — through the atmosphere. Without advection, water that evaporated over the oceans could not precipitate over land.
- **Condensation** is the transformation of water vapor to liquid water droplets in the air, producing clouds and fog.

How Earth Recycles Water

Rain in Senegal

Fog

Skiing in the snow

Sleet

How Earth Recycles Water

Earth's water cycle describes the processes that drive the movement of water throughout the hydrosphere. However, most water is "in storage" for long periods of time than is actually moving through the cycle. The storehouses of Earth water are called reservoirs.

Reservoirs

In the context of Earth's water cycle, a **reservoir** represents the water contained in different steps within the cycle. The largest reservoir is the collection of oceans, accounting for 97% of the Earth's water. The next largest quantity (2%) is stored in solid form in the ice caps and glaciers. The water contained within all living organisms represents the smallest reservoir.

The volume of water in the fresh water reservoirs, particularly those that are available for human use, are important water resources.

Volume of water stored in Earth's water cycle's reservoirs

Reservoir	Volume of water (10^6 km³)	Percent of total
Oceans	1370	97.25
Ice caps & glaciers	29	2.05
Groundwater	9.5	0.68
Lakes	0.125	0.01
Soil moisture	0.065	0.005
Atmosphere	0.013	0.001
Streams & rivers	0.0017	0.0001
Biosphere	0.0006	0.00004

Residence times in resvoirs

The residence time of a reservoir within the Earth's water cycle is the average time a water molecule will spend in that reservoir. It is a measure of the average age of the water in that reservoir; some water will spend much less time than average and some much more.

Groundwater can spend over 10,000 years beneath Earth's surface before leaving. Particularly old groundwater is called fossil water.

Average time in reservoirs

Reservoir	Average residence time
Oceans	3,200 years
Glaciers	20 to 100 years
Seasonal snow cover	2 to 6 months
Soil moisture	1 to 2 months
Groundwater: shallow	100 to 200 years
Groundwater: deep	10,000 years
Lakes (see lake retention time)	50 to 100 years
Rivers	2 to 6 months
Atmosphere	9 days

How Earth Recycles Water

Atlantic Ocean

Pink Lake, Senegal
Shallow lake with a high salt content, appears pink in color

Perito Morena Glacier
Patagonia, Argentina

Gambia River
West Africa

How Earth Recycles Water

Earth’s water cycle and biogeochemical cycling

Earth’s water cycle is very much a biogeochemical cycle as well. The flow of water over and beneath the Earth is a key component of the cycling of other biogeochemical agents. Runoff is responsible for almost all of the transport of eroded sediment and phosphorus from land to bodies of water. The salinity (dissolved salt) of the oceans is derived from erosion and transport of dissolved salts from the land. Cultural eutrophication (chemical nutrients, primarily nitrogen and phosphorous compounds) of lakes is primarily due to phosphorus, applied in excess to agricultural fields in fertilizers, and then transported overland and down rivers. Both runoff and groundwater flow play significant roles in transporting nitrogen from the land to bodies of water. Runoff also plays a part in the carbon cycle, again through the transport of eroded rock and soil.

Earth’s water cycle and climate

Earth’s water cycle is powered by solar energy. Eighty–six percent (86%) of the global evaporation occurs from the oceans. The movement of water around the world effects the temperature and climate changes. Without the cooling effect of evaporation, the greenhouse effect would lead to a much higher surface temperature and Earth would be a much warmer planet.

Earth’s water cycle and human activities

There are many human activities that alter the water cycle. Some major ones are:

- agriculture
- dams
- deforestation
- urbanization

Agriculture

Agriculture is the production of food, feed, fiber and other goods by the systematic growing-harvesting of plants, animals and other life forms. As of 2006, an estimated 36 percent of the world's workers are employed in agriculture (down from 42% in 1996); employment in agriculture is by far one of the most common occupation worldwide. However, the relative significance of farming has dropped steadily since the beginning of industrialization, and in 2006 – for the first time in history of mankind – **the services industry** surpassed agriculture as the economic sector employing the most people worldwide. Also, agricultural production accounts for less than five percent of the gross world product (an aggregate of all gross domestic products). As of 2006, an estimated 36 percent of the world's workers are employed in agriculture (down from 42% in 1996); employment in agriculture is by far one of the most common occupation worldwide.

How Earth Recycles Water

However, farming has steadily declined since the rise of industrialization, and in 2006 – for the first time in history of mankind – **the services industry** surpassed agriculture as the economic sector employing the most people worldwide. Also, agricultural production accounts for less than 5% of the gross world product (a sum of gross domestic products).

Soil conservation and nutrient management have been important concerns since the 1950s, with the most advanced farmers taking a stewardship role with the land they use. However, increasing contamination of waterways and wetlands by nutrients like nitrogen and phosphorus are concerns that must be addressed by farmers and/or far stricter law enforcement in many countries. Agriculture heavily alters Earth's water cycle.

Dams are barriers that divide waters. Dams generally serve the primary purpose of retaining water in one place until a decision is made to release all or some of the retained water, while other structures such as **levees** and **dikes** are used to prevent water flow into specific land regions. The intended purposes of dams include providing water for irrigation, for a town or city water supply, improving navigation, creating a reservoir of water to supply industrial uses, generating hydroelectric power, creating recreation areas or habitat for fish and wildlife, flood control and containing effluent (pollution) from industrial sites such as mines or factories. A few dams serve all of these purposes but some multi-purpose dams serve more than one. Dams alter the natural recycling of Earth's water, providing plenty of water for some areas and neglecting water for others.

Deforestation is the conversion of forested areas to non-forest land for use such as land for growing crops, lands for raising animals, land for urban (residential and commercial) use, area for cutting trees for wood, or creating a wasteland. Deforestation results from removal of trees without sufficient reforestation, and results in declines in habitat and biodiversity, wood for fuel and industrial use, and quality of life. Generally, the removal or destruction of significant areas of forest has resulted in a degraded environment and a redirection of the natural flow of water in the area.

Urbanization means the removal of the rural characteristics of a town or area, a process associated with the development of civilization. Demographically, the term denotes redistribution of populations from rural to urban settlements. The 2005 Revision of the UN World Urbanization Prospects report described the 20th century as witnessing "the rapid urbanization of the world's population", as the global proportion of urban population rose dramatically from 13% (220 million) in 1900, to 29% (732 million) in 1950, to 49% (3.2 billion) in 2005. The same report projected that the figure is likely to rise to 60% (4.9 billion) by 2030. Urbanization is often viewed as a negative trend but in fact it occurs naturally from individual and corporate efforts to reduce expense in commuting and transportation while improving opportunities for jobs, education, housing, and transportation. Living in cities permits individuals and families to take advantage of the opportunities of proximity, diversity, and marketplace competition.

Urbanization forces an adjustment on the recycling of Earth's water cycle.

How Earth Recycles Water

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Part III: Earth Science

Lesson 7: Earth's Geology: Rocks and Fossils

Do You Know?

Wind is moving air. Air moves because Earth's surface is heated unevenly. Water (H2o) is founded everywhere. The movement of wind and water can have many benefits for the Earth's surface and for the organisms that live on Earth. However, in severe weather like thunder storms, hurricanes and tornadoes, wind and water can be severely damaging for the Earth's surface and Earth's organisms (even fatal).

In this lesson, some of the benefits of wind and water will be presented, along with the more damaging powers of wind and rain, which occur during certain severe weather.

Earth's Geology: Rocks and Fossils

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