THE EARTH ENVIRONMENT

The word 'environment' is derived from an old French word "Environ" means 'encircle'. The environment is the physical, chemical and biological component that affects the life of an organism. The environment is the sum of all biotic (living) and abiotic (non-living) factors that surround and affect an organism. Biotic factors include the availability of food organisms and the presence of biological specificity, predators, parasites and competitors. Abiotic factors include amount of sunlight, ambient temperature, pH of the water soil in which an organism lives. Any external force, substance, or condition that surrounds and affects in any way the life of an organism becomes a factor of its environment. These factors are called environmental factors.

An environmental factor that, by its decrease, increase, presence or absence, limits the growth, metabolic processes. The environmental requirements of different organisms are individual and vary according to needs and age. Life activities of organisms are affected by the maximum or minimum amount of environmental components such as water, light, nutrients, space, temperature, and humidity.

German Scientist Justus Von Leibig formulated 'the law of the minimum', which states that if any plant is deficient in any of its essential nutrients, the plant will grow poorly, even if all other essential nutrients are abundant. However, not only too little of something is a limiting factor, but also too much may limit the growth and distribution of an organism. The concept of the effect of maximum as well as minimum has been incorporated into the law of tolerance by American Zoologist victor Ernest Shelford (1931). According to the Law of Tolerance states that the success of an organism is based on a complex set of conditions, and that each organism has certain minimum, maximum, optimal factors or combinations of factors that determine its success.

The life containing and life supporting environment of the world is restricted to a very irregular layer (5 to 20 km thick) around the globe. This thin veil of life on Earth is called the biosphere. The Earth is made up of four spheres: the biosphere, atmosphere, hydrosphere, and lithosphere.

BIOSPHERE

The global life-containing and life-sustaining environment is limited to a very thin and irregular veil or film around the world. This thin veil of living material of earth is called the ecosphere and biosphere. The word biosphere came from Greek "bios" that refers to "life" and "sphaira" that refers to "sphere". The biosphere is defined as a region on, above, and below the earth's surface where life exist. The Austrian Geologist Eduard Suess (1831-1914) first used the term biosphere in 1875 to describe the space on earth that contains life. According to Hutchinson (1970), the biosphere is that part of earth in which life exist.

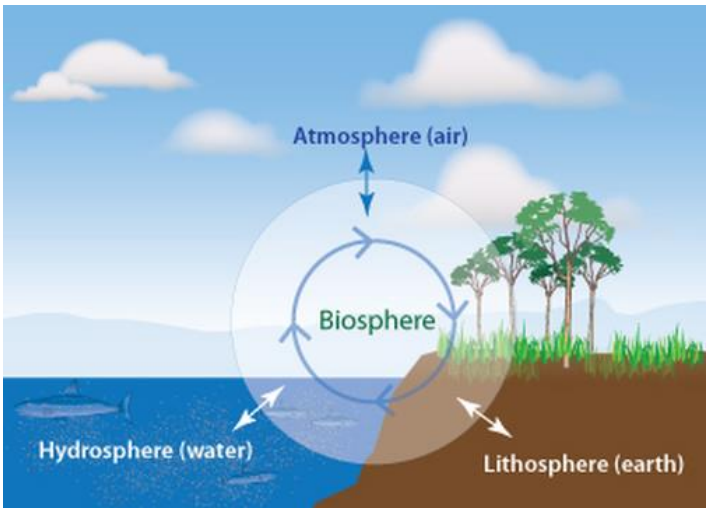
Biosphere provides the necessary environmental conditions for survival. It is the zone of the earth where land, water, air and other biotic and abiotic elements interact with each other to support life. The entire global environment is basically made of abiotic (non-living) and biotic (living) components. These components together constitute the biosphere. The abiotic global environment is composed of the atmosphere (air), the lithosphere (earth) and the hydrosphere (water), and the biotic component is made of various forms of life inhabiting in the abiotic environment.

The biosphere is one of the four layers that surround the earth along with the lithosphere (rocks), is the outer surface of earth composed of solid and rock, the atmosphere is the surrounding gaseous envelope, and the hydrosphere refers to earth's liquid water including oceans, lake and rivers.

Biosphere can be divided into many major categories of land called Biomes. A biome is a large region of earth that has a certain climate and certain types of living things. There are five major types of biomes: grassland forest, deserts, forests, and tundra, through some of these biomes can be further divided into more specific categories, such as Savanna, freshwater, marine, taiga, tropical rainforest and temperate.

Biomes are subdivided into small units which are called as zones. For example a forest biome can be divided into canopy zone and ground zone. The animals and plants of each biome have traits that help them to survive in their particular biome. Land-based biomes are called terrestrial biomes. Water-based biomes are called aquatic biomes. Temperatures, precipitation amounts and prevalent organisms characterize the biomes of the World.

Biosphere is made of different types of ecosystem. Living organism requires inorganic metabolites like water, minerals, and oxygen, nitrogen and carbon dioxide etc, for building and maintenance of lives. Living organisms obtain all such inorganic substances from the abiotic counter-parts of the biosphere. The biosphere acts as a life support system for the planet, helping to regulate the composition of the atmosphere, maintaining soil health and regulating the hydrological (water) cycle. Besides the biosphere, the three other main components of the earth are described below.



Biosphere and its components

ATMOSPHERE

The earth is enveloped by a gaseous layer called atmosphere. The atmosphere is the layer of gases which surrounds the earth from all sides and is attached to the earth's surface by the gravitational force of the earth. Gravity prevents gases that make up the atmosphere from escaping to space. Atmosphere is composed of 78% Nitrogen gas, 21% oxygen gas, 0.9% argon, and trace amounts of water vapour, carbon dioxide, methane, ozone, and sulfur dioxide. Atmosphere has four main layers. We start measuring these from sea level and move towards space. The first layer is the troposphere, then the stratosphere, and mesosphere and thermosphere. Above the thermosphere the atmosphere merges with outer space in the layer known as the exosphere. Each of these layers holds different properties. e.g., differences in temperature density, composition of gases etc. The composition of the atmosphere is almost uniform up to about 80 km altitude. The higher the level, the lighter the

gas. The atmosphere is denser closer to the Earth and thinner further away. Atmospheric pressure is closer to the Earth than farther from it. The atmosphere has an ozone layer at an altitude of about 32 to 48 km. This layer acts as a barrier that prevents the sun's ultraviolet rays from reaching the earth, which are deadly to living organisms. Among the various components of atmospheric gases, oxygen, nitrogen, and carbon dioxide are essential for the normal functioning of living organisms, as they act as metabolites of living organisms.

Structure of Atmosphere: The atmosphere is divided into five concentric layers which can be distinguished on the basis of temperature. These layers are as follows:

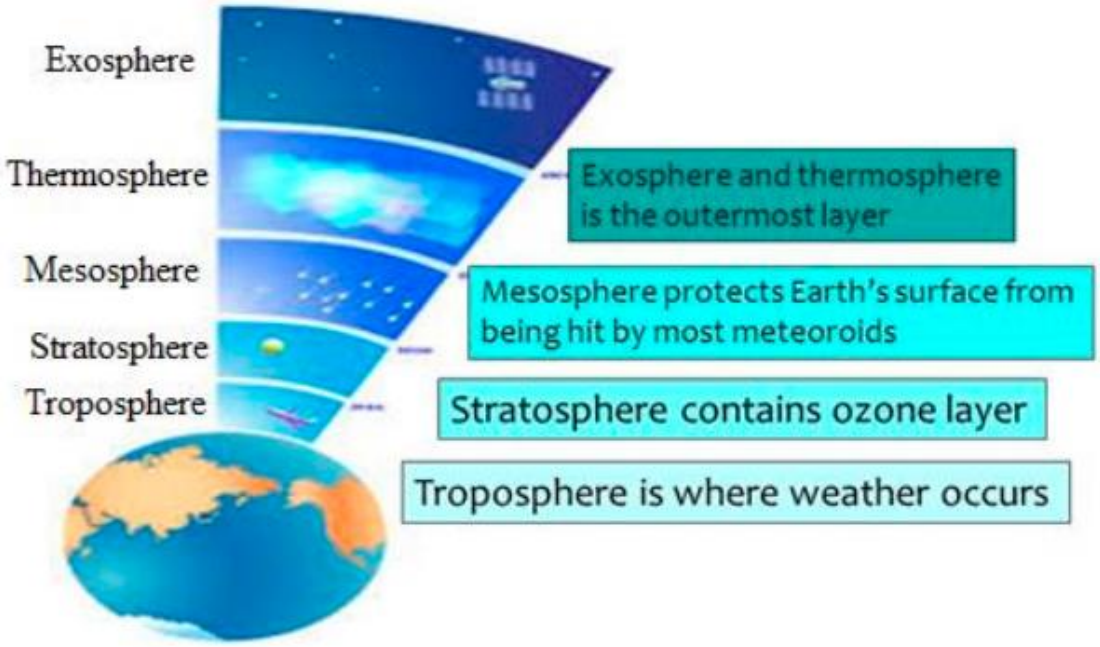
(i). Troposphere: The lowest layer of atmosphere in which man and other living organisms live is called troposphere, ("Tropos" means change) This represents the linear portion of the atmosphere that extends upto 20 km above the earth's surface. It is thin in the polar regions i.e. about 10 km from earth surface. It contains more than 90 percent of gases in the atmosphere. The important events, such as cloud formation, lightning, thundering, thunder storm formation etc, all take place in troposphere. Troposphere is characterized by weather change and steady decrease in temperature with increasing amplitude and it may decrease upto-60o c in the upper layers.

(ii). Stratosphere: The second layer of air mass extending about 30 km above tropopause is called Stratosphere (it is also called ozonosphere). The uppermost layer of stratosphere is called stratopause. In this zone the temperature shows an increase in temperature from a minimum of about -60oC to maximum of 5oC. The increase in temperature is due to ozone formation under the influence of UV (ultraviolet) rays of solar radiation. Ozone is formed from oxygen by a photochemical reaction in which solar energy (symbolized as hv) splits the oxygen molecule to form atomic oxygen which then combines with oxygen molecule to form ozone.

O_2 _____ 2O (atomic oxygen) $O_2 + O$ _____ O_3 (Ozone)

The above reactions are reversible. Ozone content of stratosphere is constant which means that ozone is being produced from oxygen as fast as it is broken down to molecular oxygen. The highest concentration of ozone (90%) in stratosphere approximately 20-25 km above, around the earth surface is known as ozonosphere.

It is important because it absorbs ultraviolet radiation of the Sun and prevents from reaching the earth surface where it would be dangerous to living organism.



Layers of atmosphere

(iii). Mesosphere: The third layer of atmosphere next to stratopause is called mesosphere. It is about 40 km in height. The mesosphere is characterized by low atmospheric pressure and low temperature. The temperature begins to drop from stratopause, goes a decreasing with the increase in the height and reaches a minimum of about -95oC at a level same 80 to 90 km above the earth surface. The upper limit of the mesosphere is called mesopause.

(iv). Thermosphere: Next to mesosphere is thermosphere, which extends upto 500 km above the earth surface is completely cloudless and free of water vapor. Thermosphere is characterized by steady temperature increase with the height from mesopause.

(v). Exosphere: The region of atmosphere above the thermosphere is called exosphere or outer space which lacks except those of hydrogen and helium. This extends upto 32190 km from the earth. Exosphere has a very high temperature due to solar radiation. The earth is magnetic, field become more important than gravity in distribution of atomic particles in the exosphere.

Importance of Atmosphere

1. The atmosphere and Sound: Sound is a form of energy that travels in waves. Sound waves cannot travel through empty space, but they can travel through gases. Gases in the atmosphere provide a source for sound to travel through, and it also allows birds, insects, and airplanes to fly through.

2. The atmosphere and living things: The gases in the atmosphere, namely oxygen and carbon dioxide, allow organisms on earth to live. Plants need carbon dioxide for photosynthesis. Through photosynthesis plants are able to use carbon dioxide to create sugar for food. The reaction for photosynthesis is:

$$6CO_2 + 6H_2O + \text{solar energy} \rightarrow C_6H_{12}O_6 \text{ (sugar)} + 6O_2$$

Animals undergo a process that allows them to use oxygen in order to convert sugar into usable energy. Plants also undergo this process in order to consume some sugars they produce. The reaction for respiration is:

$$C_6H_{12}O_6 \text{ (sugar)} + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{usable energy}$$

3. The atmosphere and Earth's temperature: The atmosphere keeps the temperature of the earth constant so that it is suitable to support life. The water vapour and carbon dioxide present in the lower layers of the atmosphere absorb the heat radiated by the earth's surface, and as such they keep the atmosphere warm even during night. Gases in the atmosphere keep out some of the Sun's scorching heat during the day.

4. The atmosphere and earth's water: The atmosphere serves an important purpose as a medium for the movement of water. The atmosphere contains a lot of water vapour and acts as an important reservoir for water. It plays significant role in the water cycle. It facilitates the formation of clouds which remains suspended until they are heavy enough to pour down on the earth as rain or snow.

5. The atmosphere and the Sun's rays: The atmosphere acts like a blanket or a glasshouse for the earth. The earth's atmosphere acts as an insulating layer that protects the earth's surface from the intense light and heat of the sun. It protects us from UV and other short wavelength light that would otherwise do a lot of damage to the DNA of living organisms. The presence of ozone layer does this by reflecting the UV rays of the Sun. Gases reflect or absorb the strongest rays of sunlight and

receives the radiation of the Sun but does not allow the insolation to escape into space. As such it keeps the earth warm.

HYDROSPHERE

All the water bodies on the earth' surface namely lakes, rivers, ponds, ocean, sea together with ice and snow; are collectively called the hydrosphere. The word hydrosphere comes from the Greek word hydro which means 'water' and 'sphere' stands for a 'round', ball-like, spherical shape. The hydrosphere is the biosphere's aquatic component and it covers about 73% area of the earth's surface. About 97 percent of the total water of the globe is found in the ocean and the rest 3 percent consists of the water of the ponds, lakes, rivers and the water obtained from snow and ice. Water is the major inorganic nutrient needed by all living organisms; hence, water is essential to all life. First life originated in water. Water is one of the main agents in pedogenesis and is also the medium for several different ecosystems. The chemical formula for water is H_2O which indicates that a single molecule of water is made up of two hydrogen atoms and one oxygen atom.

Importance of hydrosphere: Hydrosphere plays an integral role in the survival of all life forms.

1. A substance found in living cells: The hydrosphere is the source of water is a substance found in living cells. In each living cell, there is at least 75% water that promotes the cells normal functioning. The majority of chemical reactions in living organisms involve materials that are dissolved in water. Without water, no cell would survive or be able to carry out its normal functions. The hydrosphere houses the water and serves as a source and reservoir of water to living organisms.

2. Habitat for many Life forms: The hydrosphere is home to a wide variety of plants and animals, for instance, water dissolves many nutrients such as nitrite, nitrate, and ammonium ions, as well as gases such as oxygen and carbon dioxide. These compounds play an integral role in the existence of life in water.

3. Atmospheric existence: The hydrosphere contributes significantly to the current state of atmosphere. When the earth was formed, it had only a thin atmosphere. This atmosphere was comparable to mercury's current atmosphere as it was densely packed with helium and hydrogen. Helium and hydrogen were later evacuated from

the atmosphere. As the earth cooled the gases and water vapour were produced, forming the present atmosphere.

4. Control the weather: Water has a high specific heat, which means it absorbs or loses a lot of heat with small temperature changes, as well as a high latent heat, which means it absorbs or releases a lot of heat with evaporation or freezing. These properties aid in the stabilisation of plant temperatures and the surrounding environment. It plays an important role in regulating temperatures on Earth, ensuring that temperatures remain within a range suitable for life. The properties of latent heat of water are important not only because they moderate the temperature of the biosphere, but also because they play an important role in the hydrological (water) cycle by evaporating water and causing it to precipitate (condensate) as rain and dew.

5. Human requirements: Human benefit from hydrosphere in numerous ways. Besides drinking, water is used for both home and industrial purposes. It can also be used for agriculture, transportation and hydropower to generate electricity.

LITHOSPHER

The solid component of earth is called lithosphere. The term lithosphere is derived from the Greek words ‘lithos’, meaning stone, and ‘sphaira’, meaning ball or globe. It is the terrestrial component of the biosphere. The uppermost part of the lithosphere that chemically reacts to the biosphere, atmosphere and hydrosphere through the soil forming process is called the pedosphere. The soil provides food, shelter, anchorage and concealment from predators to living organisms. Under the lithosphere is the asthenosphere, the weaker, deeper and hotter part of the mantle. It is a solid rock layer where extreme pressure and heat cause the rocks to flow like a liquid. The asthenosphere's rocks are not as dense as those in the lithosphere. Tectonic activity is the most well-known feature associated with the earth's lithosphere. A lithospheric plate, also known as a tectonic plate, is a massive and irregular slab or solid rock that usually includes both the oceanic and continental lithospheres. These tectonic plates vary in size. The majority of tectonic activity occurs at the plates' boundaries, where they may collide, tear apart, or slide against each other. Thermal energy (heat) from the lithosphere's mantle allows for the movement of tectonic plates. Thermal energy makes the lithosphere's rocks more elastic. Tectonic activity in the lithosphere is responsible for some of Earth's most

dramatic geologic events, including earthquakes, volcanoes, and deep ocean trenches. The lithosphere can be shaped by tectonic activity: At rift valleys and ocean ridges, where tectonic plates are shifting apart from one another, both oceanic and continental lithospheres are the thinnest.

Lithosphere is multilayered and includes following three main layers:

1. Crust: Crust is the outermost layer of the earth about 8 to 40 km above mantle. Its surface is covered with soil supporting rich and varied biotic communities on which humans and animals live and plants grow. Silica (Si) and aluminium (Al) are major constituent minerals.

2. Mantle: Mantle lies between the core and crust. It is the second layer of the earth. It extends about 2900 km above the core. This is in a molten state. It is made up of magnesium and silicate rich iron. It is the chief source of magma that finds its way to the surface during volcanic eruptions.

3. Core: Core lies beneath the mantle. The core is the central fluid or vaporized sphere having diameter of about 2500 km from the centre and is possibly composed of nickel-iron. Core is divide into two sub-zones:

(a). Solid inner core: It is the centre and the hottest layer of the earth. Thickness of solid inner core is 1,250 km and its temperature is about 5500-7000 degree C. It is composed of nickel and iron, solid due to extreme pressure.

(b). Liquid outer core: Its temperature is about 6100 to 4400 degree C and composed of iron and molten nickel. Outer core spins, creating the earth's magnetic field that protects from solar wind.

Types of lithosphere

Lithosphere can be mainly divided into oceanic and continental lithosphere.

1. Oceanic lithosphere: The oceanic lithosphere is found in ocean basins and is associated with the oceanic crust. It is denser than the continental lithosphere and is composed primarily of ultramafic mantle and mafic crust (oceanic crust). As a result, the oceanic lithosphere is much younger than the continental lithosphere because new oceanic lithosphere is constantly being produced at mid-ocean ridges and recycled back to the mantle at subduction zones. The oceanic lithosphere thickens and moves away from the mid-ocean ridge as it ages. This thickening is caused by

conductive cooling, which converts hot asthenosphere into the Lithospheric mantle and causes the oceanic lithosphere to become increasingly dense with age.

2. Continental lithosphere: The continental lithosphere is connected to the continental crust and has direct contact with the atmosphere. The continents and continental shelves are formed by layers of sedimentary and igneous rock. This layer is mostly made up of granite rock.

Importance of Lithosphere

1. Different types of rocks such as sedimentary, igneous and metamorphic rocks are found in the lithosphere.

2. Lithosphere helps to provide the necessary nutrients required to the plants. It provides grasslands, forests and is a rich source of minerals. The Lithosphere is largely important because it is the area that the biosphere (the living things on earth) inhabits.

3. Lithosphere is the major source of fuels such as petroleum, coal and natural gas. When the biosphere interacts with the lithosphere, organic compounds can become buried in the crust, and dug up as coal, oil and natural gas that we can use for fuels.

4. Tectonic plates shift due to convection currents lower down in the mantle, and this can cause the formation of mountains, earthquakes and volcanoes. Earthquakes and volcanoes help in the growth of new vegetation and life as they give rise to fertile soil and lands.

5. The lithosphere serves as a source of minerals and elements, such as copper, magnesium, iron, aluminum.