UNIT-1
OVERVIEW OF ENVIRONMENT

by

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Environment

Environment is defined as everything that surrounds us.

It essentially includes two parts

(i) Physical Condition such as air, water, land form etc, which are interlinked with the survival of the ecosystem and development of an individual or a community.

(ii) Social and cultural conditions such as ethics, aesthetics, economics etc. on which the behavior of an individual or community is dependent.

Environmental Science

Environmental Science is multi-disciplinary science involving chemistry, physics, life science, agriculture, medical science, public health, sanitary engineering etc.

It is the science of chemical phenomena in the environment.

In broad sense, it is the study of the

- **sources**
- **reactions**
- **transport**
- **effect**
- **fate of chemical species in the air, water and soil**

and the effect of human activity upon these.

Therefore, an understanding of the basic concepts of environmental chemistry is essential not only for all chemists but also for all non-chemists engaged in environmental science, engineering and management.

Environmental Segments

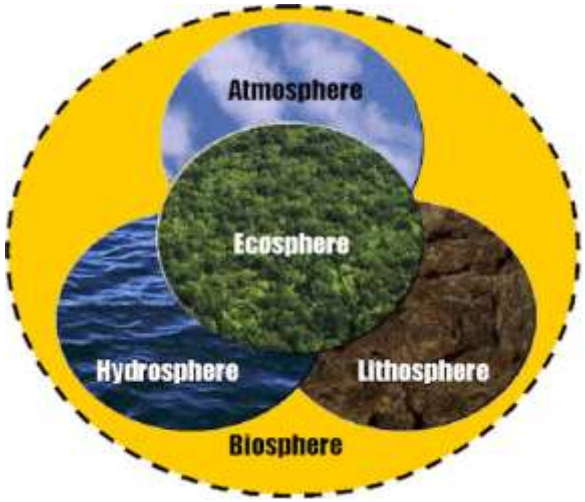
➢**Earth is the only planet on which life exists. It consists of three components Lithosphere (Land), Hydrosphere (Water) and Atmosphere (Air).**

➢**Life originated and evolved because of this unique combination of the three components and was ideal and favourable for life.**

➢**The life supporting zone of the earth where atmosphere, hydrosphere and lithosphere meet, interact and make life possible, is known as biosphere.**

The environment consists of various segments like

- **Atmosphere**
- **Hydrosphere**
- **Lithosphere**
- **Biosphere**



✓ **The lithosphere, hydrosphere and atmosphere are non-living components of the environment and are known as abiotic.**

The importance of different segments of the environment is discussed as follows:

Atmosphere:

The atmosphere plays a vital role for the survival of life in this planet

i)The atmosphere is the protective blanket of gases which is surrounding the earth. It protects the earth from the hostile environment of outer space.

ii) It absorbs the IR radiations emitted by the sun and re-emitted from the earth and controls the temperature of the earth.

iii) It allows the transmission of significant amounts of radiation only in the regions of 300-2500 nm (near UV, visible and near IR) and 0.01-40 meters (radio waves) i.e. it filters tissue damaging UV radiation below 300 nm.

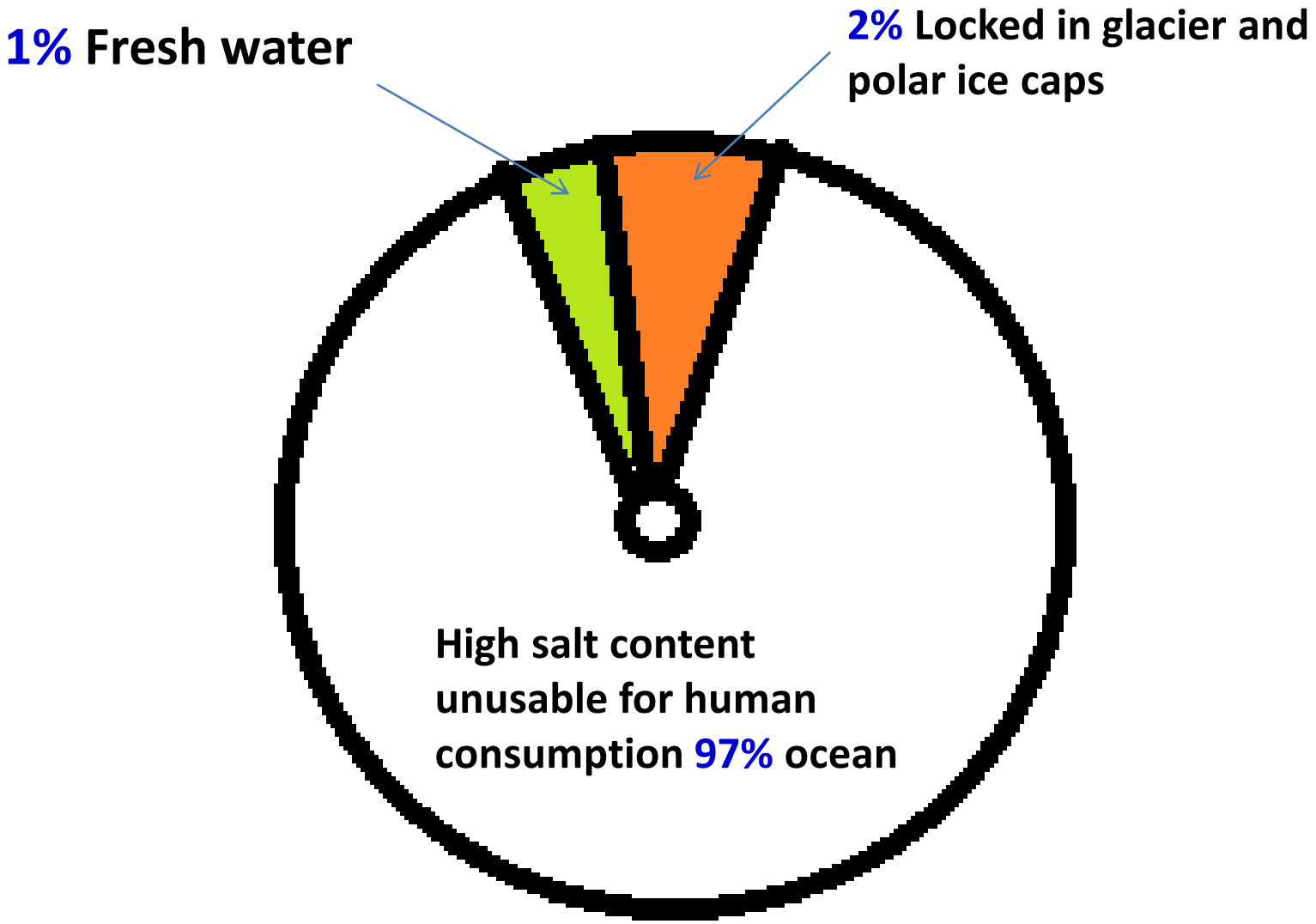
iv) It acts as a source for CO_2 for plant photosynthesis and O_2 for respiration.

v) It acts as a source of nitrogen for nitrogen fixing bacteria and ammonia producing plants.

vi) The atmosphere transports water from ocean to land.

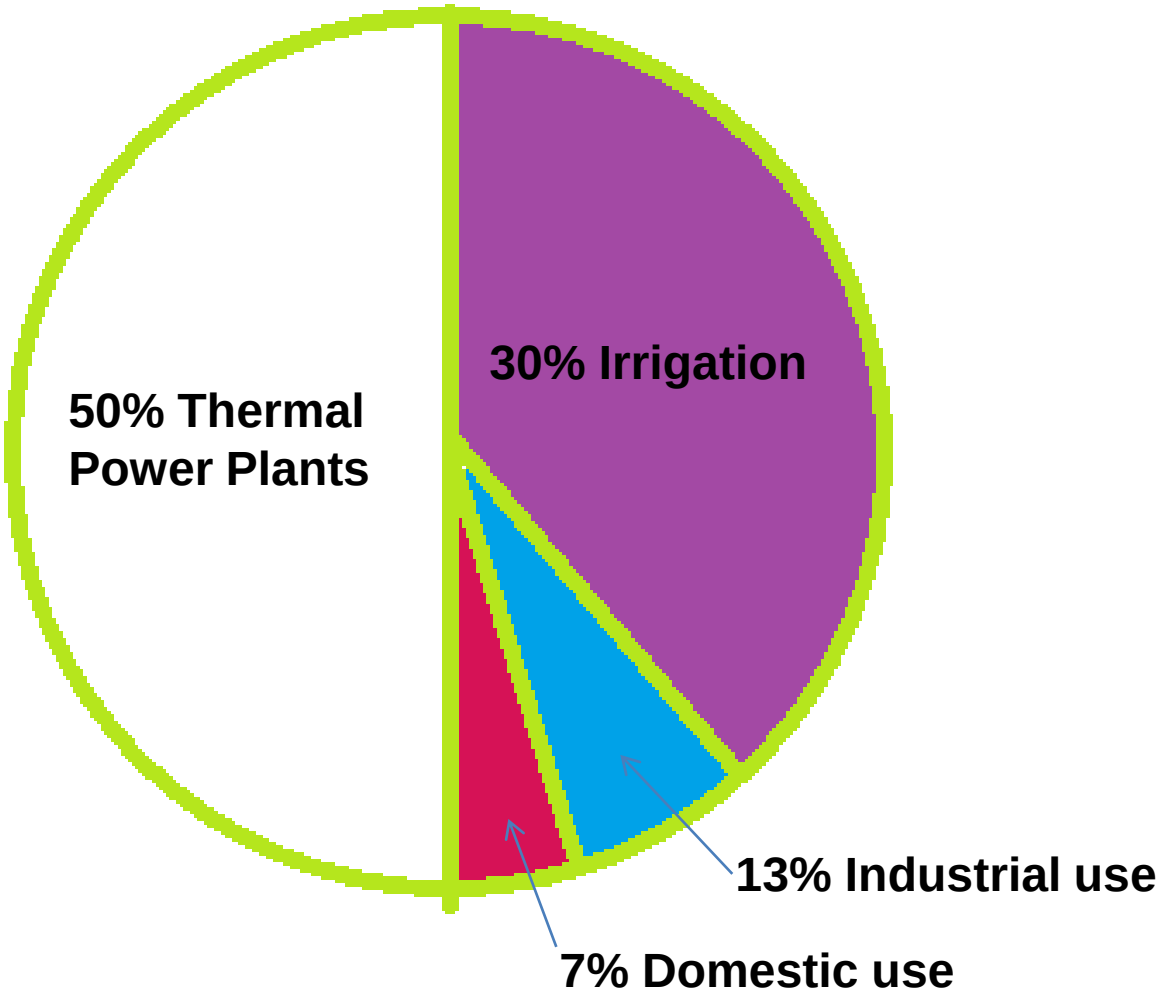
Hydrosphere:

The hydrosphere is a collective term given to all different forms of water. It includes all types of water resources such as oceans, seas, rivers, lakes, streams, reservoirs, glaciers, polar ice caps and ground water. The distribution of earth´s water as follows


1% Fresh water
2% Locked in glacier and polar ice caps
High salt content unusable for human consumption 97% ocean

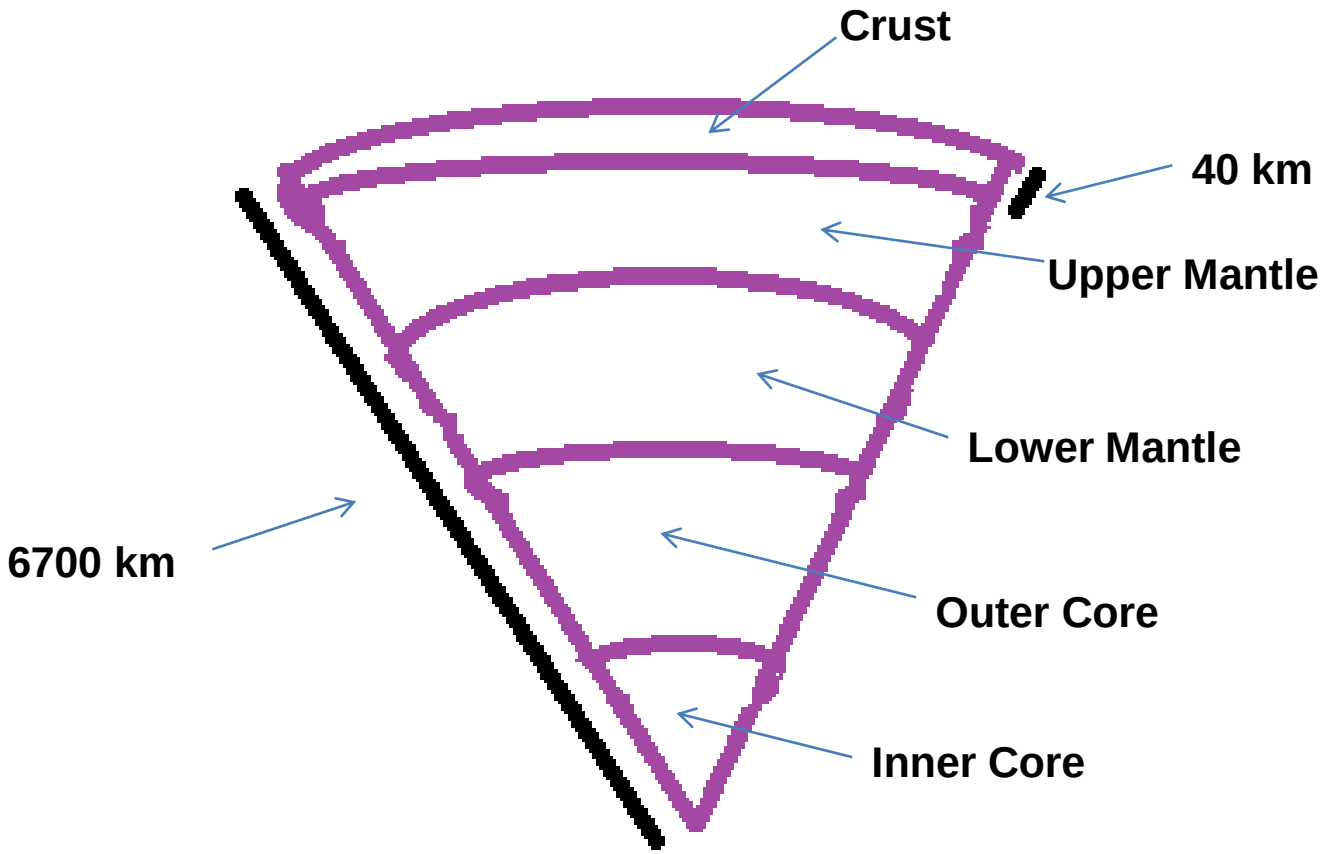
Use of Fresh water

The 1% of total fresh water in the river, lake and streams and ground water is for human consumption and this is the use of fresh water as follows:



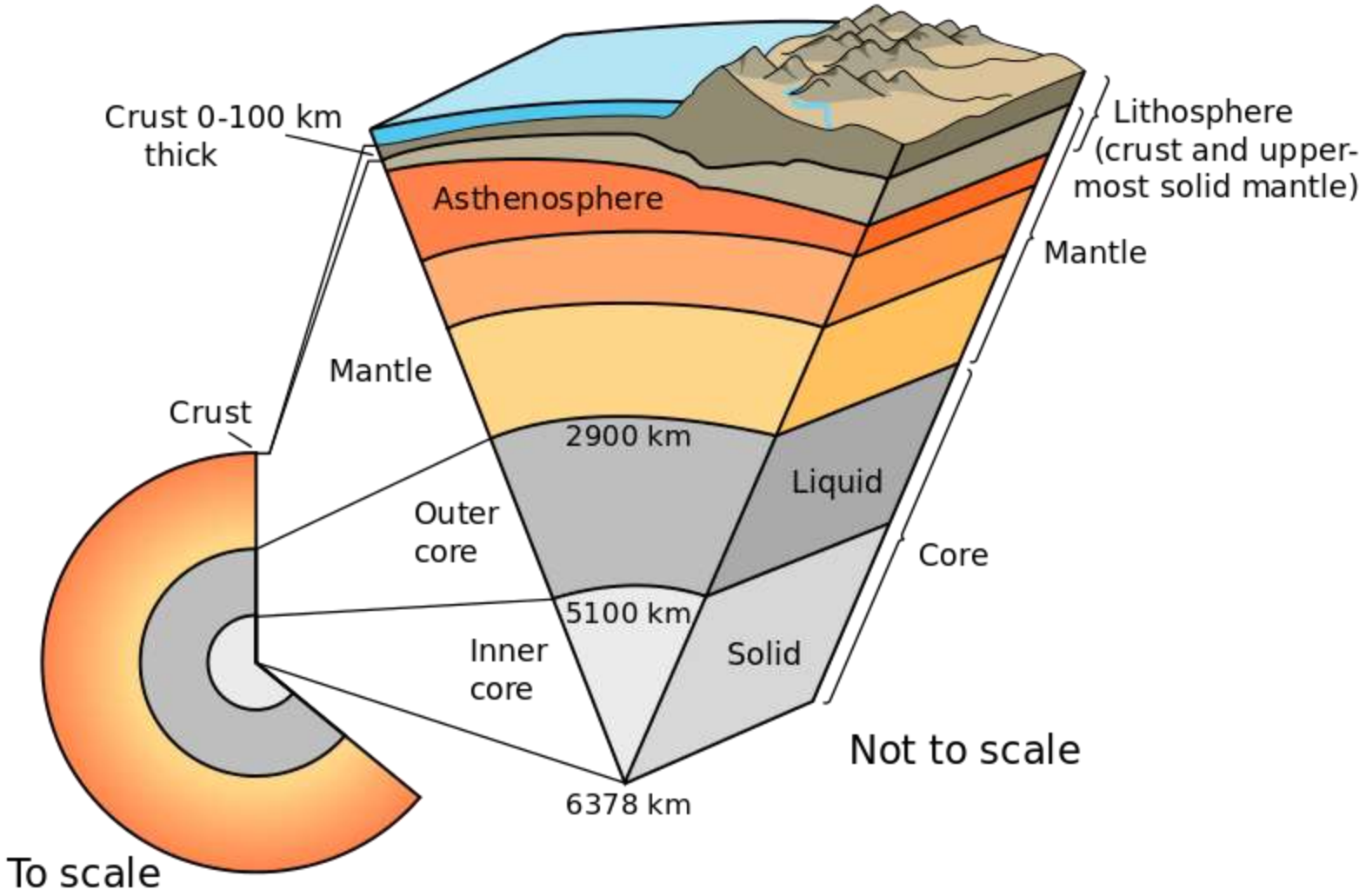
Lithosphere

The earth is divided into various layers, as shown in the figure:



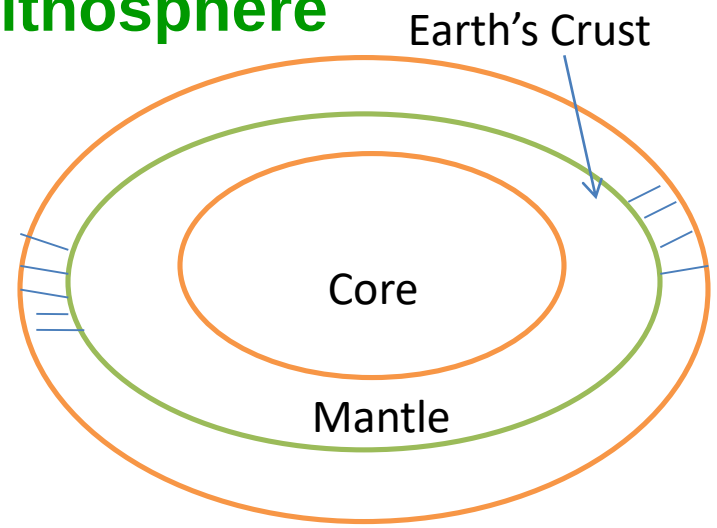
Layers of earth

Chemical Composition of Lithosphere



The lithosphere includes the crust and the uppermost mantle, which constitute the hard and rigid outer layer of the Earth.

Chemical Composition Lithosphere



The solid component of the earth is called lithosphere. It consists of three zones- crust, mantle and core.

Crust:- The outer most part of Lithosphere consisting of different Types of rocks is known as crust. Its thickness varies from 64 to 96 km. Each crust contains Mainly oxygen, aluminum, calcium, magnesium, iron etc as major elements. It is divided into two parts soil and sima.

The upper part of the earth crust is generally made up of silicon (Si) and aluminum (Al) known as soil. The average density of this part is 2.7 and extends up to 17 km. Sima, the lowers part of the crust is composed of silicone (Si) and magnesium (Mg).

The density of this part is 3.0.

The line where soil and sima layer meet with each other is known as 'convad discontinuity'

Mantle

- Mantle is situated just below the crust. The thickness of this layer is approximately 2880 km. It is consisted of two parts.

- The upper part of the mantle is called “asthenosphere”. The major elements of this layer are chromium (Cr), iron (Fe), silicone (Si) and magnesium (Mg).

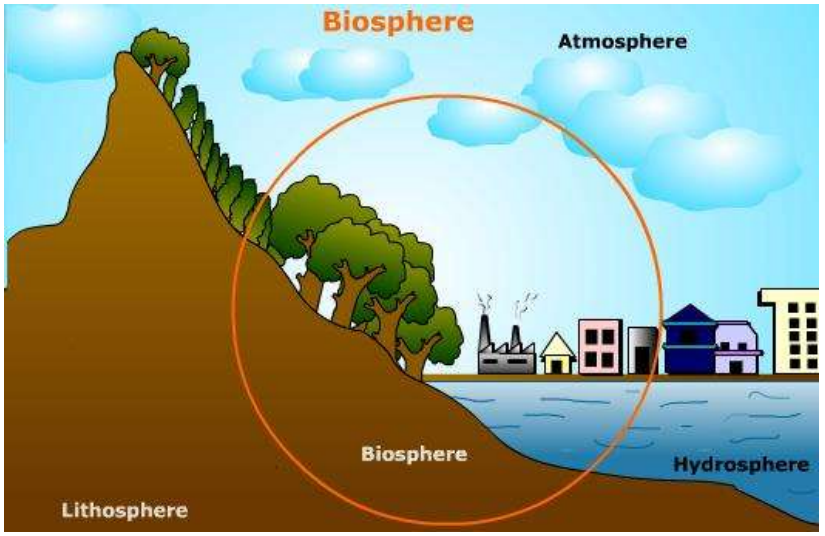
- The lower part of the mantle is known as mesosphere. It contains nickel (Ni), iron (Fe), silicon (Si) and magnesium (Mg).

Core

- The centre part of the lithosphere is called core. It is also known as barysphere.
- The thickness of this layer is about 3500 km.
- Temperature, mass and density of this core zone is very high in comparison to the lithosphere.
- The major components of this layer are iron (Fe), and nickel (Ni) with some other components like sulphur (S), silica (Si), Cobalt (Co).
- The core can be divided into two parts. The outer core containing molten metal and inner core containing more solidified metallic minerals.

Biosphere

The biosphere refers to the kingdom of living organism and their interactions with the environment, which includes atmosphere, hydrosphere and lithosphere.



- **The biosphere is very large and complex and divided into smaller units called ecosystem.**
- **Plants, animals and microorganisms which live in a definite zone along with physical factors such as soil, water and air constitute an ecosystem.**
- **Within each ecosystem there are dynamic interrelationships, between living forms and their physical environment.**
- **Their interrelationships manifest as natural cycles such as hydrological cycle, oxygen cycle, nitrogen cycle, phosphorous cycle and sulphur cycle.**
- **The natural cycles operate in a balanced manner providing a continuous circulation of essential constituents necessary for life, which stabilizes and sustains the life processes on earth.**

The biotic or living components include plants, animals and microbes living on the earth. A constant interaction between the abiotic and biotic components of the biosphere results in the transfer of food and energy, which makes it a dynamic but stable system. The biosphere is the biggest biological system. It consists of smaller functional units known as ecosystems or ecological systems.

ATMOSPHERE STRUCTURE

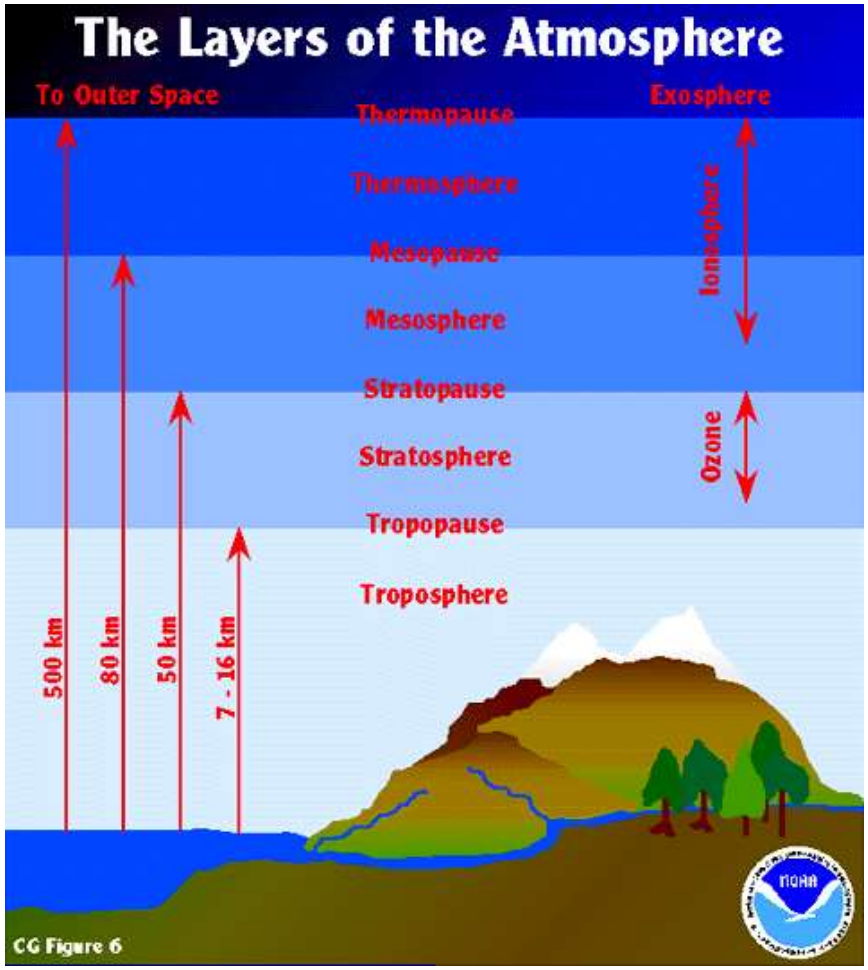
The atmosphere may be broadly divided into four regions

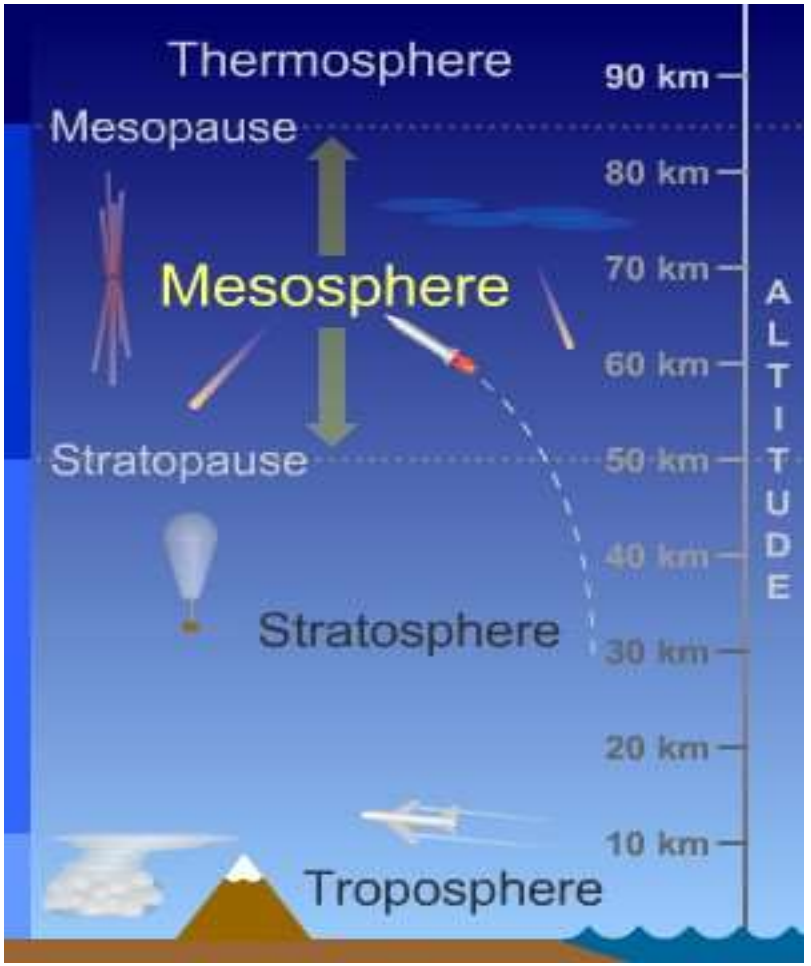
Region	Altitude (km)	Temperature range (^0C)	Important chemical species
Troposphere	0 - 11	15 to - 56	N_2, O_2, CO_2, H_2O
Stratosphere	11 - 50	-56 to -2	O_3
Mesosphere	50 - 85	-2 to -92	O_2, NO
Thermosphere	85-500	-92 to 1200	O_2^+, O^+, NO^+

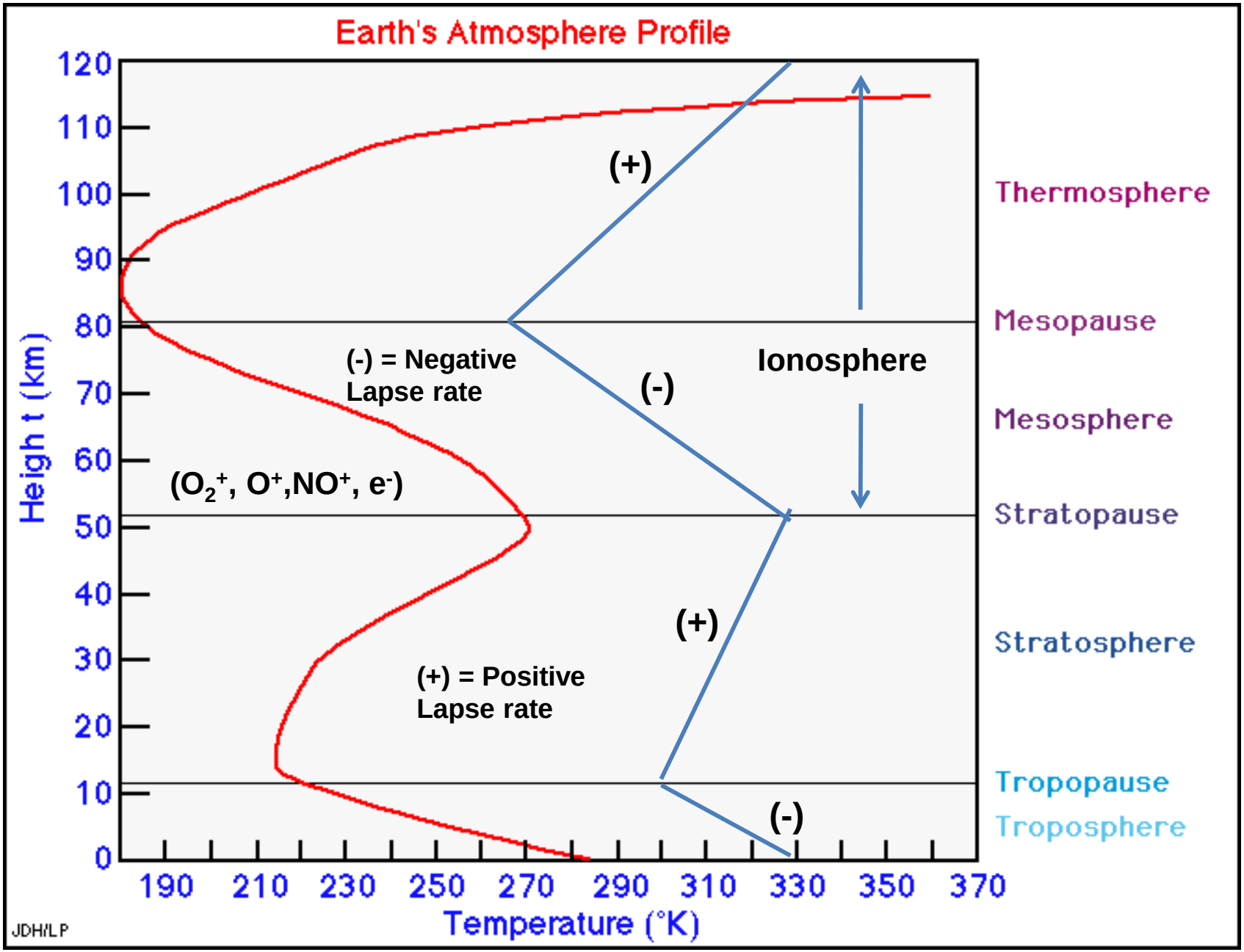
Different layers of Atmosphere

The atmosphere may be broadly divided into four regions:

(i) Troposphere (ii) Stratosphere (iii) Mesosphere (iv) Thermosphere






Earth's Atmosphere Profile
120
110
100
90
80
70
60
50
40
30
20
10
0
Height (km)
190
210
230
250
270
290
310
330
350
370
Temperature (°K)
(+)
(-)
(+)
(-)
(-) = Negative Lapse rate
(+) = Positive Lapse rate
Ionosphere
(O2+, O+,NO+, e-)
Thermosphere
Mesopause
Mesosphere
Stratopause
Stratosphere
Tropopause
Troposphere
JDH/LP

Troposphere

- **The troposphere contains 70% of the mass of the atmosphere. Here the air is far from uniform with respect to density and temperature.**
- **Density decreases exponentially with increasing altitude.**
- **In respect of composition, the troposphere is more or less homogeneous in the absence of air pollution, mainly due to the constant circulation of air in this region.**
- **The water content however varies due to hydrological cycle.**
- **The temperature in the troposphere falls of uniformly with increasing altitude. Thus, this layer follows (–) ve lapse rate. (*The lapse rate is defined as the rate of decrease with height for an atmospheric variable. The variable involved is temperature*)**

- **The air near ground level is heated by radiation from the earth. Some of the absorbed solar energy radiates as heat waves from the lower region of the troposphere to the middle and finally to the upper troposphere. Thus there occurs a gradual decrease in temperature with height.**

- **The colder layer (-56^{O} C) at the top of the troposphere is called the tropopause, which marks temperature inversion i.e., transition from negative to positive lapse rate.**

Stratosphere

- **The stratosphere is having a positive lapse rate, *i.e.* the temperature increases with increase in altitude with maximum of -2 ^{0}C which is in the upper limit of stratosphere.**
- **Ozone in this region absorbs ultra violet (UV) radiation and therefore raises the temperature causing a positive lapse rate.**
- **It (Ozone) plays an important role in the stratosphere. It acts as a protection shield for life on the earth from the injurious effects of the sun's ultra violet rays.** and at the same time, it supplies the heat sources for partitioning the atmosphere into a quiescent stratosphere and turbulent troposphere.

$$O_3 + h\vartheta\ (220\text{ -}330\text{ nm}) \longrightarrow O_2 + O$$

- **The hotter layer (-2^{0}C) at the top of the stratosphere is called the stratopause, which marks temperature inversion i.e., transition from positive to negative lapse rate.**

Mesosphere

- **The mesosphere shows negative lapse rate *i.e.*, temperature falls with increasing altitude.**

- **Concentration of ozone is very low in this region and decreases rapidly with increase in height. Thus there is a decrease in the absorption of solar radiation and the temperature falls to – 92 ^{0}C.**

- **The dominant chemical species found in this region are O_2 and NO.**

- **The colder layer (-92 ^{0}C) at the top the of the mesosphere is called mesopause, which marks temperature inversion *i.e.*, transition from negative to positive lapse rate.**

Thermosphere

- **The thermosphere starts immediately above the mesosphere and the temperature rises once again, giving a positive lapse rate.**

- **The atmospheric gases like oxygen and nitric oxide, split into atoms here and also undergo ionization after absorption of solar radiation in the far ultra violet (UV) region.**

- **The ionosphere is high electrical conductor as it contains charged particles. Before the induction of satellites, the ionosphere was important to worldwide communication due to its ability to reflect short radio waves back to earth.**

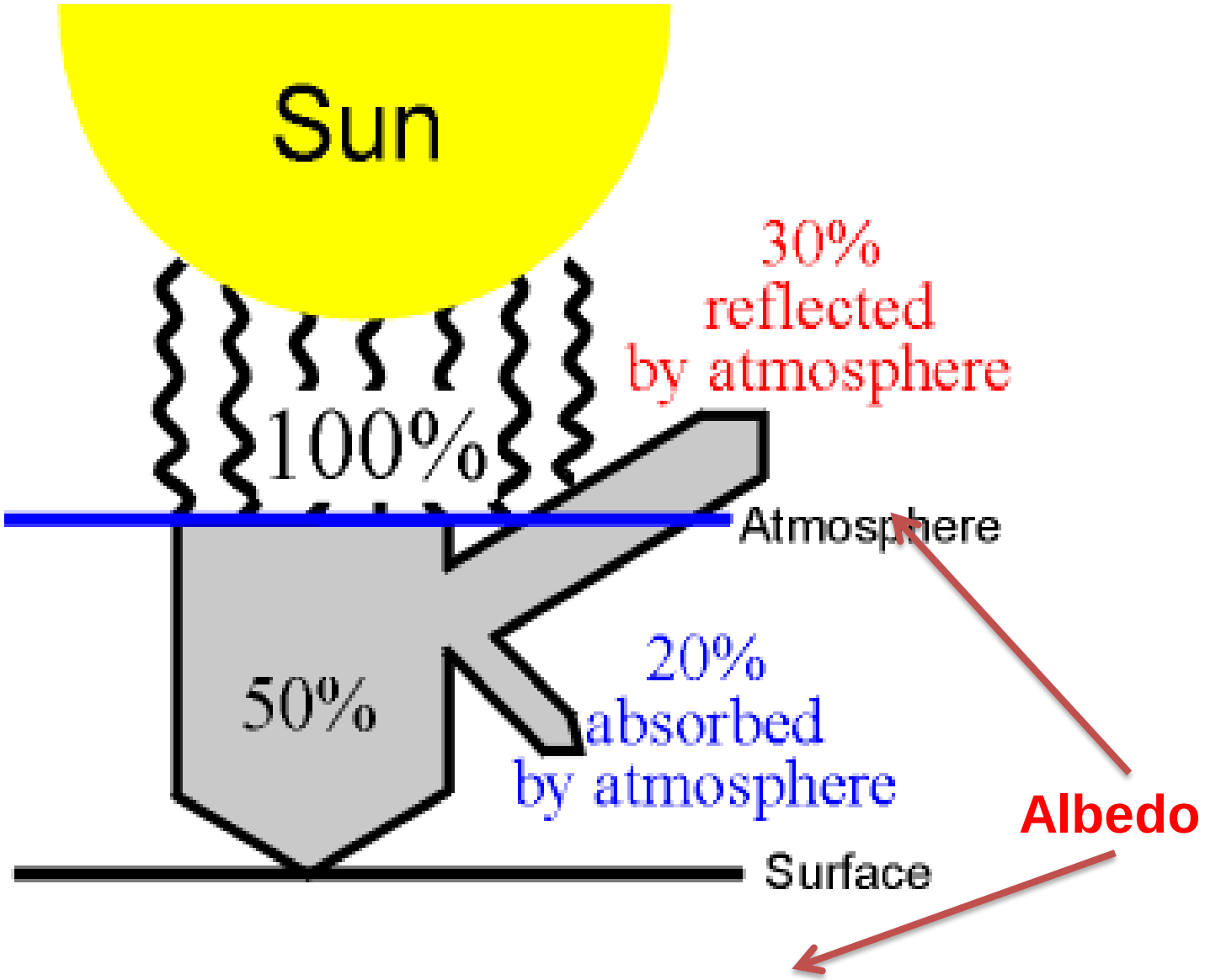
Earth's Radiation Balance

- **Earth receives a very large input of energy daily from the sun and maintains a steady state by giving off the bulk of this energy at the same rate.**

- **The earth absorbs radiation mainly in the visible region but emits radiation at the same rate in the infrared region.**

- **The solar flux incident on earth's upper atmosphere is 1340 watts.m^2 /min. If all this energy was absorbed by earth, then it would have evaporated long ago.**

- **The earth absorbs about 66% of solar flux incident on it *i.e.*, 19.5 kcal/ m^2/ min, while it reflects and scatters back into space 34% (albedo) of the flux.**



Note:- Fraction of sunlight reflected and scattered back to the atmosphere is known as Albedo.

Factors influencing Albedo

- Increasing agricultural and industrial outputs can upset the earth radiation balance by changing the albedo.

- Deforestation and consequent soil erosion increase the albedo.

Heat Transfer

When two objects are at different temperatures, heat will be transferred from the hotter object to the cooler one.

There are three modes by which heat can be transmitted from one point to another: i) Conduction ii) Convection iii) Radiation

i) Conduction: The mechanism by which heat energy is transmitted directly from a hotter part of an unequally heated body to a colder part is called conduction. Example: Conductive heat transfer is usually associated with solids, as one molecule vibrates the next in the lattice.

ii) Convection: **When there is a liquid or gas between them that means heat energy is transmitted by the random translational movement of the molecules. Convective heat transfer occurs when a fluid at one temperature comes in contact with a substance at another temperature. *For ex.*, warm air in a house in the winter that comes in contact with cool wall surface will transfer heat to the wall.**

iii) Radiation: **The mechanism by which heat energy is transmitted from one place to another without the agency of any intervening medium is called radiation. *For ex.*, The heat of the sun reaches the earth by way of radiation because most of the space between sun and the earth is devoid of any material medium.**

Radiation heat transfer

Black Body

- **A black body is an idealized radiator. It absorbs all the radiation incident upon it and heated by this radiation to a higher temperature than any other body.**

- **Consequently, when a black body is heated it radiates more intensely than other bodies at the same temperature.**

- **A black body is defined to be a perfect emitter as well as a perfect absorber.**

These black body radiation curves have the following characteristics:

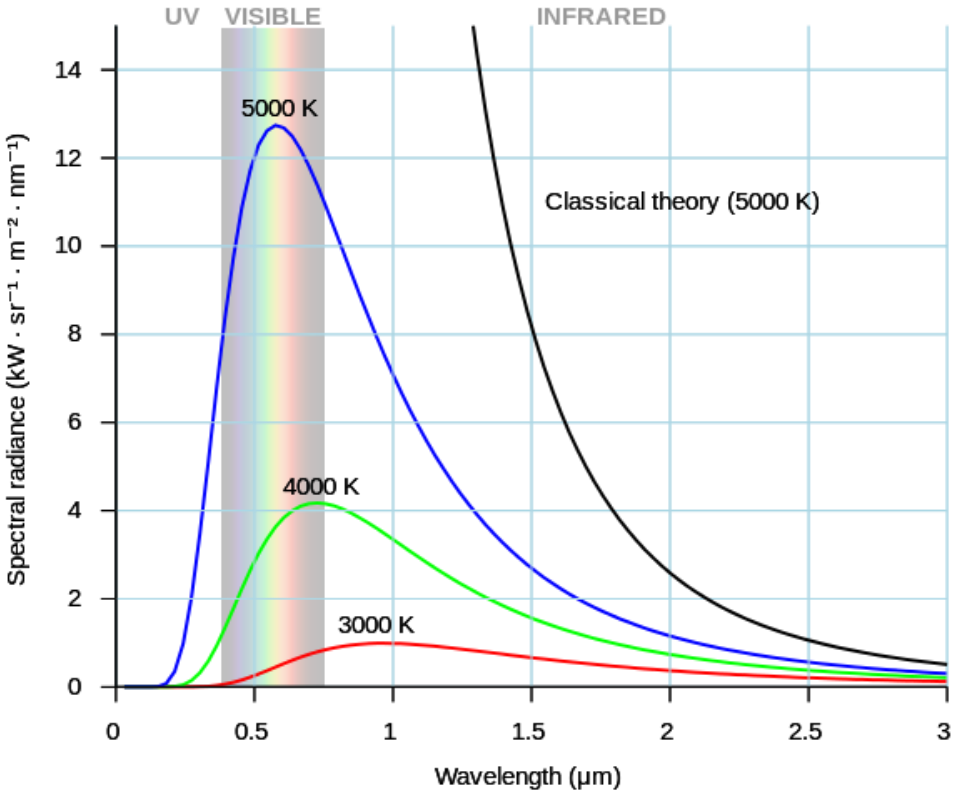
1. At a particular temperature, energy is not uniformly distributed among wavelengths.

2. For each temperature, there is a particular wavelength at which the energy radiated is the maximum.

3. The position of the maximum, shifts towards lower wave length with increase in temperature.

4. The higher the temperature, the more pronounced is the maximum.

5. The total area below the curve corresponds to the total energy radiated. This area increases with increase in temperature.



Wien's Displacement Law

The wave length of maximum intensity is inversely proportional to the absolute temperature of the black body. Or in other words, the product of absolute temperature (T) at which particular curve is measured and the wavelength (λ_{max}) at which the curve has a maximum, is a constant.

$$\lambda_{max} T = b \qquad (2.898 \times 10^3 \, mK)$$

Stefan Boltzmann Law

It states that the intensity of the total radiation from a black body is proportional to the fourth power of its absolute temperature.

$$E = A\sigma T^4$$

Where E is the rate of emission of radiant energy per unit area per unit time.

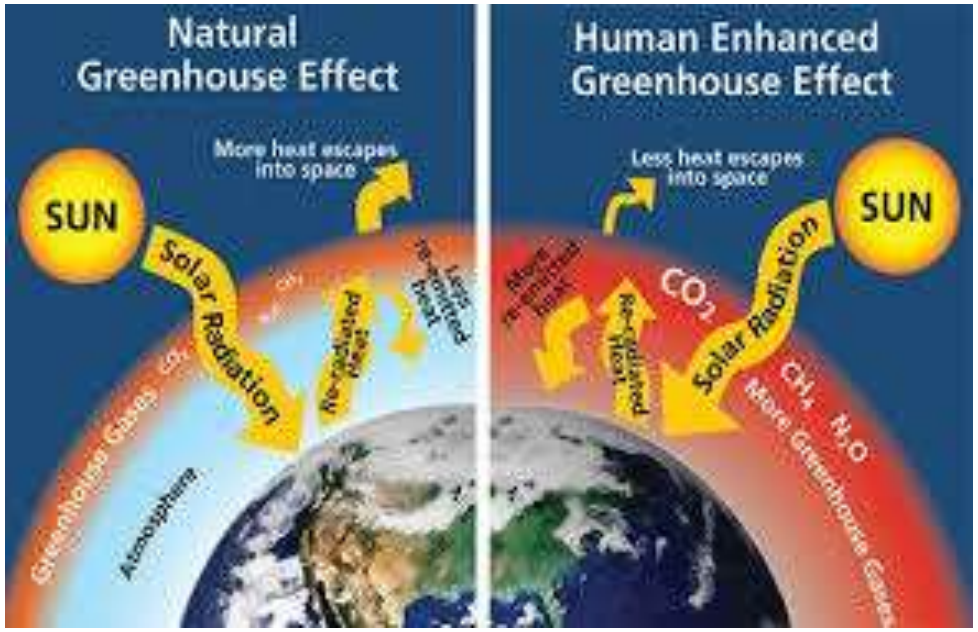
A is the surface area of the object

T is the absolute temperature

σ is the Stefan Boltzmann constant

E is directly proportional to T^4

Stefan Boltzmann's law gives the total rate at which energy is radiated from a black body, it does not tell us anything about the wave length emitted.



Unit 2: Air, Water and Soil Pollution