COMPOSITION, STRUCTURE AND IMPORTANCE OF THE ATMOSPHERE.

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COMPOSITION, STRUCTURE AND IMPORTANCE OF THE ATMOSPHERE

INTRODUCTION

The atmosphere of the earth is a vast expanse of gases enveloping our entire earth. Within this envelope, we are surviving and all our activities are confined. It is made up of several gases, water vapour and minute particles suspended in the gaseous substance of air. The atmosphere extends several hundred km above the earth surface. It is not uniform at every height we climb above, but it has drastic changes with height. The atmosphere is composed of several layers. At the transition zones of the layers, the change is very sharp but within a layer, the changes are slow. In this module, we will discuss about the composition and structure of the atmosphere. Apart from these, our concern will also be there to through light on its importance and utility of the atmosphere for us as well as for the entire living organisms.

MEANING OF COMPOSITION OF ATMOSPHERE

The literal meaning of composition is 'ingredients' or 'constituents' of something. In another words, it is a manner by which something is made up of. When we apply the same meaning with atmosphere, it signifies the items or the elements with which our atmosphere is composed. Our atmosphere is composed of numerous gases and other substances, hence, it is a mechanical mixture of the gases, water vapour and dust particles. Let us discuss about the composition of atmosphere.

COMPOSITION OF ATMOSPHERE

The envelope of atmosphere around the earth, a mechanical mixture of numerous gases and other substances are very important to all living organisms of the planet. The four major gases – nitrogen, oxygen, argon and carbon dioxide together constitute 99.99% of the total volume of dry air. The maximum concentration is of nitrogen with more than 78 percent while the oxygen is little less than 21 percent (Table 1).

Table 1: Atmospheric Gases

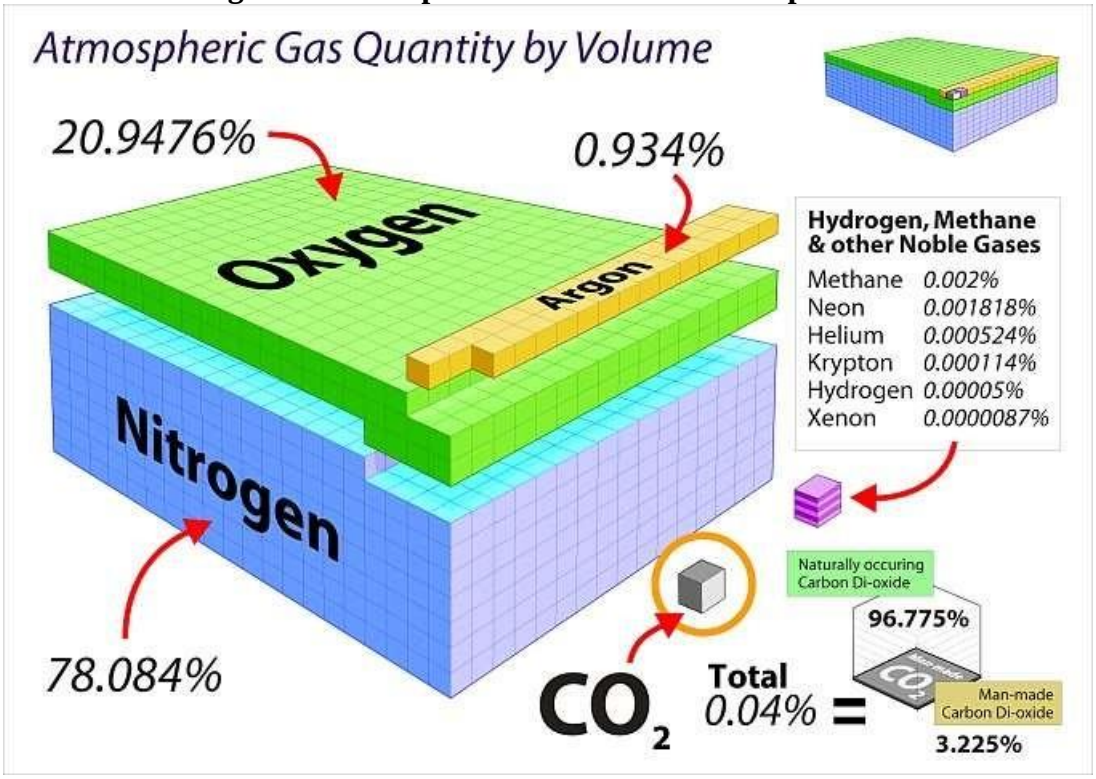
Groups	Gases	Volume % of dry air
Major Gases	1. Nitrogen	78.084
	2. Oxygen	20.9476
	3. Argon	0.934
	4. *CO_2	0.04

Minor Gases (***** are also variable gases)	5. *Methane	0.002
	6. Neon	0.001818
	7. Helium	0.000524
	8. Krypton	0.000114
	9. Hydrogen	0.00005
	10. Xenon	0.0000087
	11. *Ozone	0.00006
Variable Gasses (CO_2, methane and ozone gases are also variable)	12. Water vapour	Variable amount
	13. Dust particles	Variable amount
	14. Aerosols	Variableamount

NITROGEN: Nitrogen is the most abundant found in atmosphere constituting 78.084 percent to the total volume of dry gases Figure 1). This is almost chemically inactive and have nothing to do with any sort of chemical actions in the atmosphere. It does not combine freely with other elements, hence, it is termed as neutral substance. This gas is found beyond a height of 100 km, but its concentration is below 50 km height from the sea level. This gas is significant for the growth and reproduction in plants and animals. Certain bacteria in the soil are capable of converting a very small amount of atmospheric nitrogen into nitrates and fix it to the soils and water bodies to be consumed by animals and plants. This process is called as Nitrogen fixation. The nitrogen fixed in the earth's surface is again converted and sent back to the atmosphere by bacterial action through a chemical reaction called denitrification.

OXYGEN: It is the second largest gas of the atmosphere constituting 20.9476 percent of the total dry atmospheric gases (Figure 1). It is very essential for the survival of many of the living organisms of this planet. It is chemically very active gas. It is combined with several other elements and forms varied compounds. Oxygen is vital for combustion of fuels. When anything burns, oxygen is consumed and helps in burning that substance. Though oxygen is found beyond 100 km but it is reasonably in good proportion within 16 km of height. With increasing height, the amount of oxygen decreases very rapidly. On mountain slope, the available oxygen for breath is very scanty and the mountaineers are supposed to carry oxygen for them.

Figure 1: Atmospheric Gases and their Proportions



ARGON: In terms of percentage, argon is the third largest gas in the atmosphere constituting 0.934 percent of total dry atmosphere (Figure 1). It is an inert gas and chemically it is inactive. It is also found in the earth's crust and sea water. It is used in electric bulb and fluorescent lights.

CARBON DIOXIDE: It is the fourth abundant gas of the atmosphere. It is densest gas and found in lower parts. It is found upto a height of about 30 km, it is concentrated in the lower strata. Its percentage is very low, i.e., 0.04 percent (Figure 1) but it is most vital for the growth of vegetative life of biosphere. It is transparent to the incoming solar radiation but does not allow to escape the same. And hence, it is called as greenhouse gas. It plays a very crucial role in increasing the global temperature.

It is also known as variable gas as its amount is dependent upon the combustion, human activities and vegetative cover of the planet. The carbon dioxide is reaching to the atmosphere due to several human activities like energy utilization, transport, industry, agriculture, waste generation etc. (Figure 2). Apart from these human induced sources, some natural sources are like plant respiration and release to air from stored carbon in the rocks through natural process of denudation. All these are leading to increase in the atmosphere. This gas is on rise with the advancement in economic development of the society. Economically developed countries/ regions are generating big amount of carbon dioxide gases which may be seen from Figure 3.

Figure 2: Different Sources of Carbon Dioxide

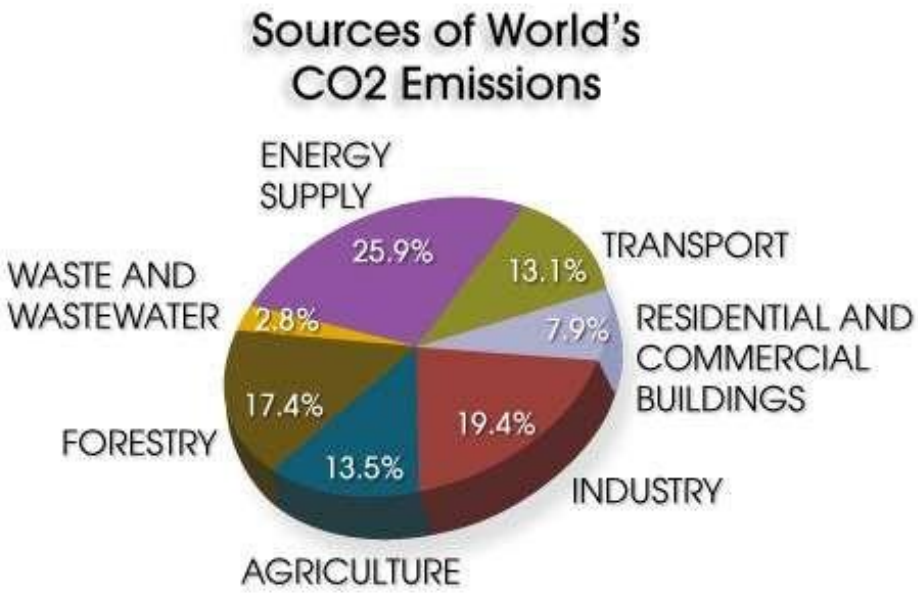
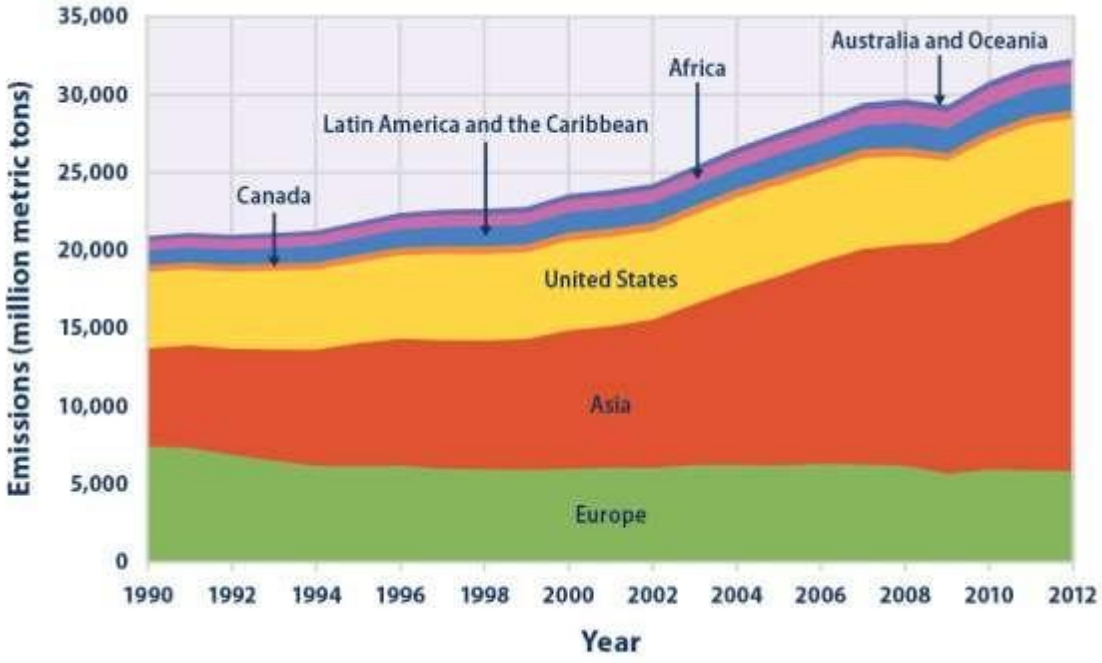


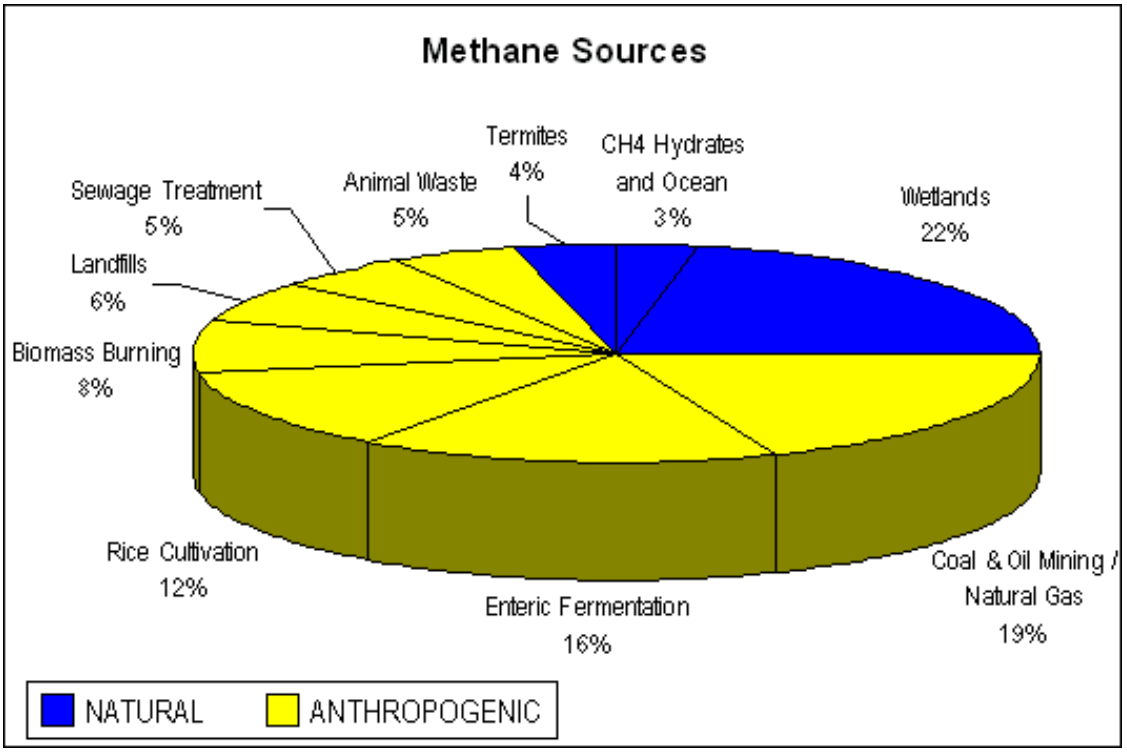
Figure 3: Global Carbon Dioxide Emission by Region: 1990-2012



METHANE: Methane is the also a greenhouse gas which absorbs the radiation and cause more temperature of the air. Paddy cultivation also generates methane in the air. It is also produced from the wetlands and waterlogged soils and released in the atmosphere. Fossil fuel is also a

source to release of methane in the atmosphere. Its amount in the atmosphere is variable. The numerous sources of methane can be seen from Figure 4.

Figure 4: Different Sources of Methane



Source: https://icp.giss.nasa.gov/education/methane/intro/methanesources.gif

OZONE: Ozone's concentration lays in a belt between the heights of 15 to 50 km of atmosphere. Instead of normal two atoms of oxygen, ozone has three atoms of oxygen formed together denoted by O_3. It is formed when atmospheric oxygen molecules are broken by ultraviolet solar radiation. It may even be formed at the time of electrical discharge during thunderstorms. This gas is also termed as variable as its formation and disintegration is dependent upon numerous activities. Though ozone is very less in quantity (0.00006 percent), this thin layer is very significant for the survival of living world as it absorbs the dangerous ultraviolet rays and protects the earth. Neon, helium, krypton, hydrogen, xenon are other minor gases. Some gases are still extremely less in quantity; they are termed as trace gases. Important among them are ammonia, carbon monoxide, Sulphur dioxide, nitrogen dioxide, nitrous oxide and Sulphur hexafluoride etc.

WATER VAPOUR: Water vapour is small in amount but it is one of the most important part of atmosphere with respect to the distribution of vegetation and life. Water vapour exists all the time in the atmosphere but with varying degree of amount depending upon the season (temperature condition) and the supply of water for evaporation and evapotranspiration. Air is hardly completely dry. In summer, the water holding capacity of the air is large as the temperature is high while in winter it is low.

Availability of sufficient amount water on the earth surface or water body in an area witness greater vapour while less availability of avoidance of the same shows low vapour. Examples

may be taken as equatorial region rich in water bodies (high vapour) and subtropical hot desert region with less to no water availability (low vapour). Though, vapour and air both are in gaseous form, their mixing and movement are quite natural but the same homogeneity it not seen.

At any particular point of time, the amount of vapour is not more than four present of the total volume of atmosphere. It is found in the troposphere only and its concentration is in the lower level. About 90 percent of the total vapour lays below six km. It is estimated that the about 50 percent is within two km of height. Water vapour plays a vital role in keeping the earth warm as it has greenhouse characteristics.

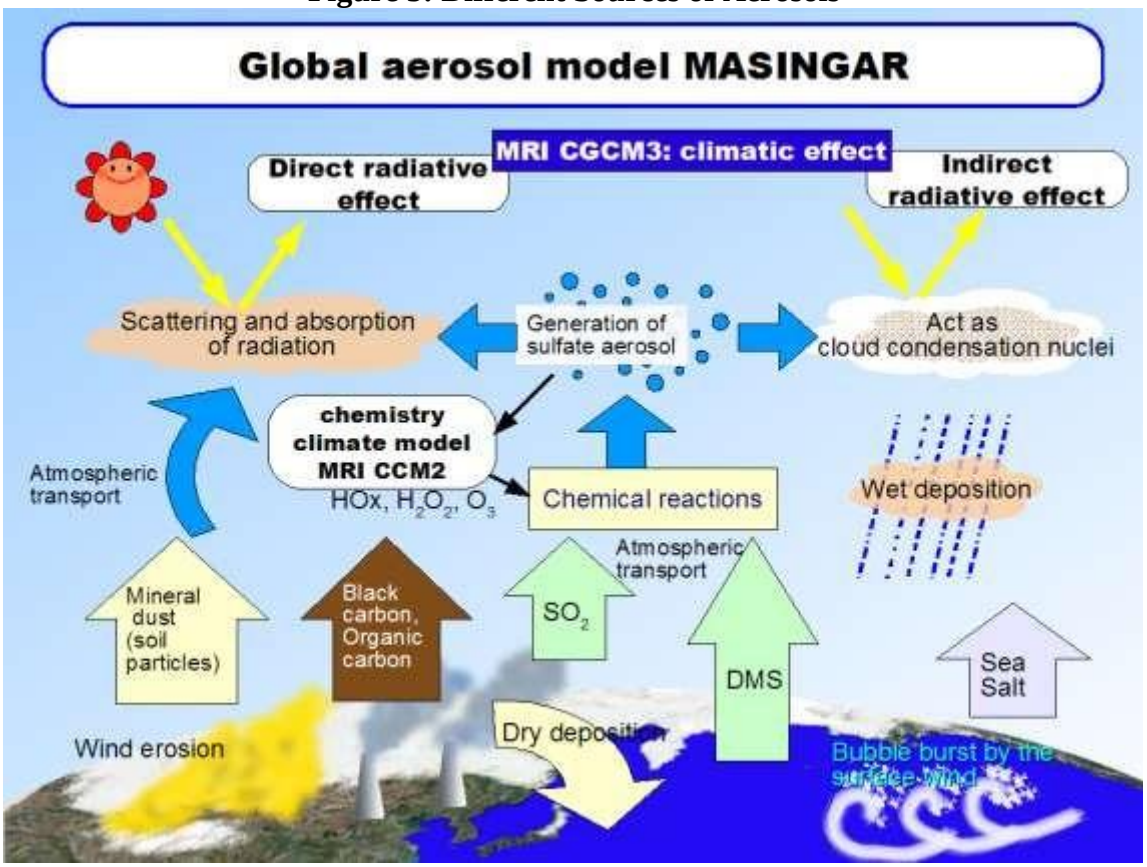
DUST PARTICLES: Huge amount of dust particles are available in the lower layer of atmosphere in a suspended form. These dust particles are solid substances generated from various sources and being carried by winds. Greater velocity wind has greater amount of dust particles. It is not only a matter of suspended solid particles, they are transported to great distances as well. They vary widely in sizes. They may be big sized suspended only when the drafting ability of the wind is great, but settles swiftly when the carrying capacity of the wind is reduced. You must have observed yourselves too during gales/ storms.

Huge number of microscopic dust particles are suspended even in completely calm air. Dust particles are variable and it is more during dry seasons as the soils are loose and easily carried by winds, but reverse is the case when it is rainy season when they are settled and compacted. Over the globe, it is less in equatorial and polar areas while more in subtropical hot desert areas. Minute dust particles are found several km above the surface while the coarse sized are abundant near the surface. Microscopic particles are nuclei for condensation and precipitation and they have a great importance in this respect.

AEROSOLS: Aerosols are extremely fine-sized solid particles or liquid droplets which continue to be in suspended form in gas for very-very long time. They could be seen when their concentration is more otherwise they are invisible. Aerosols themselves are non-gaseous microscopic substance released in the atmosphere from various sources – natural and human created. They could be pollen, minute earthly dust, sea salt, carbon soot from burning fuels, volcanic dust etc. Human activities also help the aerosols to enter the atmosphere. Their concentration is more over the industrial and urban areas. Burning of fossil fuels and generation of smoke also pump the aerosols in the air. Therefore, the source of aerosols are both natural as well as human generated (Figure 5). They are grouped into two – hygroscopic (moisture absorbing and retaining) and non-hygroscopic (moisture non-absorbing). Hygroscopic aerosols form the nuclei for condensation and in this way, they help in precipitation.

From the above description, it is fairly obvious that our atmosphere is made up of innumerable minute molecules of several gases about which a discussion has been presented above. Apart from that several non-gaseous substances are also available in the air which are part and parcel of the atmosphere. They have their own significance and play very essential role for the earth to be a live able planet.

Figure 5: Different Sources of Aerosols



MEANING OF STRUCTURE OF ATMOSPHERE

Structure means the arrangement of different part into one. In another words, it is the skeleton or organization or anatomy of a whole by looking at the relationships with its parts. According this background, the study of different parts of the atmosphere and the relationship with its parts is said to be the structure of the atmosphere. Vertically, the atmosphere is divided into different layers/ parts. Therefore, the study of different layers is known as structure of atmosphere.

Structure of Atmosphere

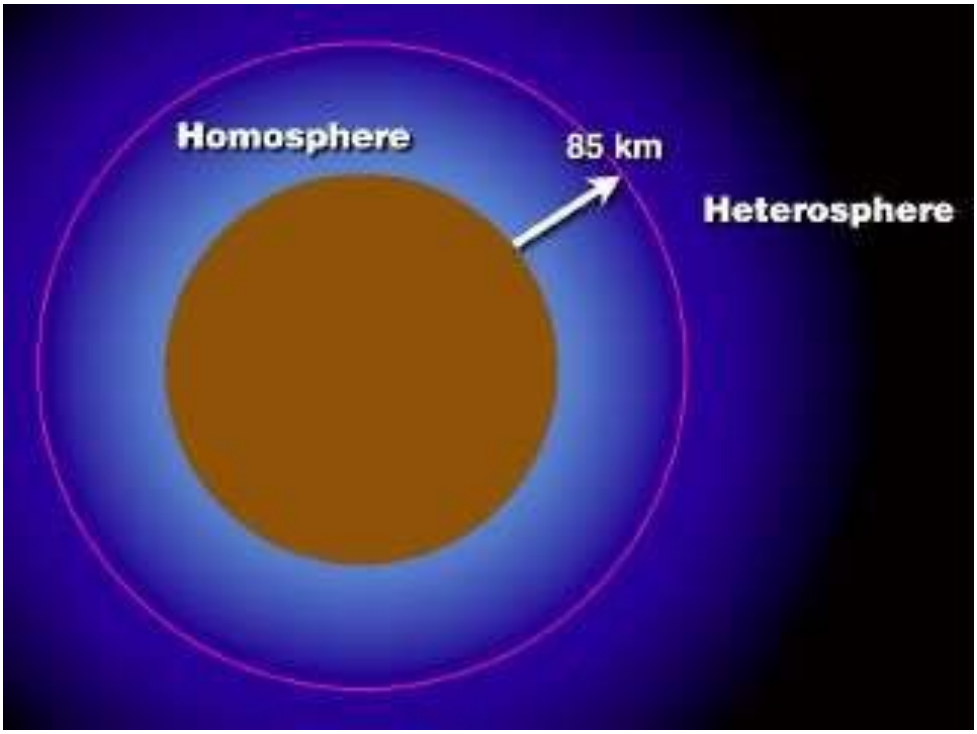
Based on chemical composition, the atmosphere is classified into two. They are homosphere and heterosphere.

HOMOSPHERE

Homosphere is that part of atmosphere where the chemical composition of the air is uniform or similar. It is the lowest layer in terms of chemical composition. It extends from the earth's/ ocean surface to about 85 km (Figure 6). The density of the air changes very rapidly with increasing altitude but the proportion of the major gases found there remain alike throughout this layer with the exception of water vapour, pollutants, ozone and some trace/ very minor gases.

On the basis of the changes in temperature, the atmosphere is divided into five layers (Figure 7) out of them, three lower layers falls under homosphere (i.e. within 85 km of altitude). They are troposphere, stratosphere and mesosphere.

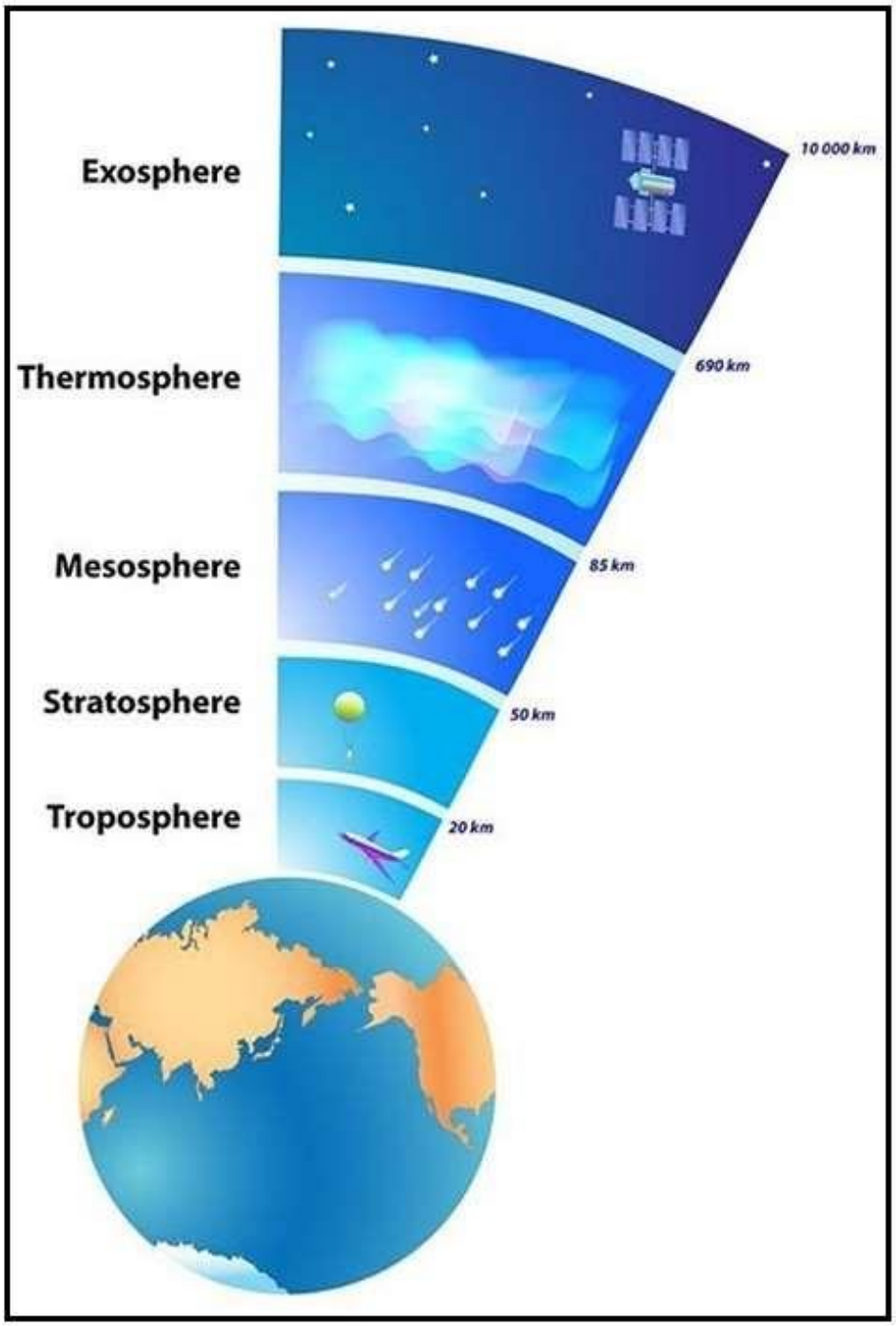
Figure 6: Homosphere and Heterosphere



TROPOSPHERE: It is the lowest and densest layer of the atmosphere. It extends till a height of about 8 km over pole but over equator, it is 18 km. About 80 percent of the total mass of the atmosphere lays in this layer. With increase in height, the temperature keeps on declining till the limit of this layer. On an average, the decrease in temperature with height is 6^0Celsius par km. The upper boundary is known as troposphere laying between 8 and 18 km. At this level, the average temperature reaches to minus 50^0 to minus 60^0 Celsius (Figure 8). Water vapour is found in this layer in abundance and about 99 percent of the total atmospheric water vapour is concentrated here but wide variation is seen in terms of height and longitudes. Vapour plays very vital role in regulating the temperature of the earth by creating greenhouse effect.

All weather phenomena are occurring in this layer only. Troposphere is the home of all types of clouds, atmospheric turbulence and mixing of the air. Both horizontal and vertical mixing is quite prominent here. In fact, the term troposphere is derived from the Greek word 'tropos' means 'turn'. Sphere is signifying 'ball' or a structure which is round in shape attaining a three-dimensional space. Therefore, the troposphere is a three-dimensional object with turning or mixing characteristics. Every sort of living life is confined to the biosphere which include land water and air. The upper limit of troposphere is tropopause which is a transition zone another upper layer known as stratosphere.

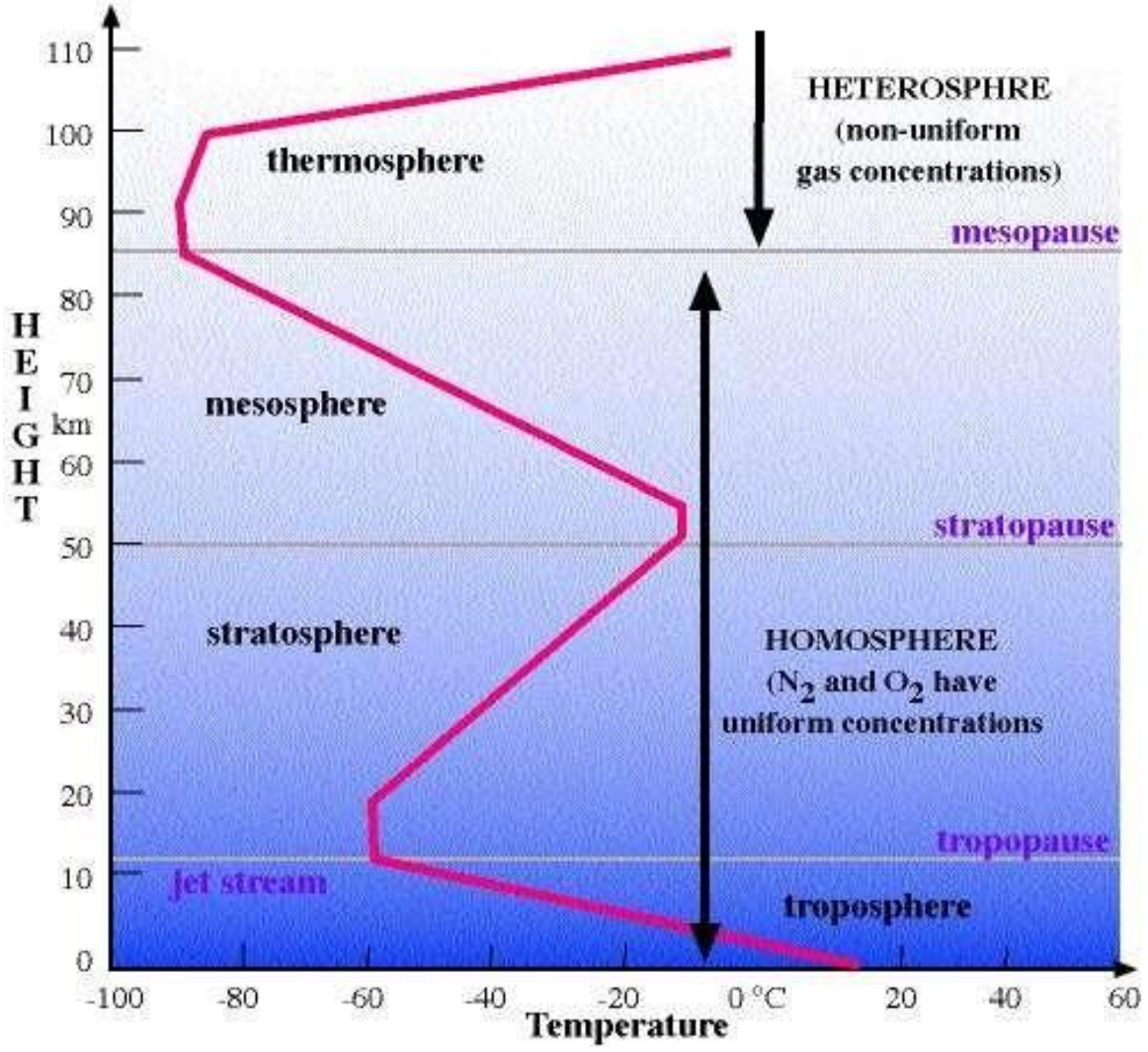
Figure 7: Different Layers of Atmosphere



STRATOSPHERE: Stratosphere is the upward second layer as well as middle layer of the homosphere. It starts from tropopause to approximate height of 50 km. The temperature at the tropopause remains almost constant till the height of 20 km. After that, it starts increasing and continue the trend till the height of 50 km (Figure 8). At this level, the estimated temperature is about minus 10^0 to minus 15^0 Celsius. Though the temperature is on rise, but there is no atmospheric turbulence. This layer is completely free from clouds and other weather conditions. That is why, it has an advantage for flying long-distance supersonic jets/

aeroplanes through this layer. The increase in temperature in this layer is caused by absorption of solar radiation by ozone (O_3). Ozone is abundant in this layer and its 90 percent is concentrated (found between 15 km to 50 km) in this layer only. The upper limit is stratopausewhich is a very narrow strip of transition zone beyond which mesosphere is found.

Figure 8: State of Temperature in Different Layers of Atmosphere



Stratosphere is also termed as ozonosphere, a layer made up of ozone. This layer protects the living world of the planet from the harmful effects ultra-violet rays. The ozone depletion and hole over Antarctic was discovered in 1985. Since then, we have observed that this layer has reached to a dangerous level of depletion of ozone. The main ozone depleting substances are received from the release of chlorofluorocarbon (CFCs), hydro-chlorofluorocarbon (HCFCs) and carbon tetrachloride. When the molecules of chlorine atom come into contact with ozone (O_3), it turns O_3into O_2 which is normal oxygen. One chlorine atom can destroy more than a lakh atoms of ozone. Therefore, the chain of depletion is very serious. O_3turned into O_2, an ordinary oxygen molecule is not capable to absorbing ultra-violet rays.

MESOSPHERE: Mesosphere is the third but the upper-most layer of the homosphere. After this layer, heterosphere starts. The literal meaning of mesosphere is the middle sphere. It is separated by tropopause below from troposphere and mesopause on the top from thermosphere. It is extended from 50 km to 85 km from the earth's surface (Figures 7 and 8). The air pressure is very low. It is 1 millibar at the lower limit whereas it is 0.01 millibar at the highest limit. This layer is characterized by decreasing temperature and the coldest/ lowest atmospheric temperature is recorded in this layer. The lowest temperature estimated near the mesosphere is around minus 130^0Celsius. It is colder that the lowest temperature recorded over Antarctic.

Between 75 to 85 km from the earth, noctilucent clouds are normal affairs in the summer nights between 50^0 to 70^0 north and south latitudes. Its literal meaning is night shining. It is a deep twilight seen only when the sun is on horizon but the sunlight is still falling at that height. The seen clouds are made up of ice crystals. Meteoric dust particles work like nuclei for ice crystallization which are falling as well as produced due to burning of meteor caused by friction.

Figure 9: Noctilucent Clouds

HETEROSPHERE

The atmosphere laying beyond the homosphere is termed as heterosphere. The term itself is self-explanatory and it is used for that part of atmosphere where the air is not uniform. In this part of atmosphere, the air is rare and the molecules are wide apart. Relatively heavier gas molecules are concentrated in the lower part whereas the lighter are forced to be above.

Beyond 85 km height, the composition of the atmosphere with increasing altitude vary significantly. The mixing of the gases is not possible as the turbulence is not happening there. Different layers of prominently different gases are nitrogen layer, oxygen layer, helium

layer and hydrogen layer are differentiated. However, the heterosphere, is divided into two main spheres – thermosphere and exosphere.

THERMOSPHERE: This sphere extends from mesopouse i.e., 85 km to about 650 km from earth. The temperature is on rise in this layer due to absorption of solar radiation by small amount of oxygen molecules present. It is highly dependent upon the solar activities. The temperature reaches beyond 1200^0C at an altitude of about 350 km but by 650 km it may even rise to 2000^0C. This much high temperature is primarily defined by average speed with which molecules are moving. Because of this, the temperature may be high. The effectiveness of this temperature is not that great. Its exposure to astronaut, if they are coming out from the capsule, is not affecting at all.

The Aurora is conspicuous phenomena observed in this layer. It is a striking display of light and are maximum between 10pm to 2am in the magnetic polar region of northern and southern hemispheres. It is known as Aurora Borealis (Figure 10) in the northern and Aurora Australis in southern hemisphere. They are referred as northern and southern lights.Charged particles coming from the solar flare reaches to the earth's upper atmosphere. These charged particles collide with nitrogen and oxygen molecules present there in rarity. The collusion results into innumerable little surges of lights. The scattering of these lights seen is very beautiful and magnificent.

Figure 10: Aurora Borealis over Alaska, 16 February 2017, Poker Flat Research Range

EXOSPHERE: Exo means external. Therefore, exosphere the external or the outer most layer of the atmosphere. Its lower boundary starts from the thermopause (650 km) to the limit from where the void space begins. This limit is estimated to be about 10000 km. This much distance is little less than the diameter of the earth. It is really a very big size of the limit of the atmosphere. In exosphere, very light gases are traced and they are hydrogen and helium. Their molecules are spaced very widely. Beyond the upper limit of exosphere, the space is considered to be void.

IMPORTANCE OF THE ATMOSPHERE

Atmosphere is very crucial for every types of lives surviving on the earth. Without atmosphere, there is least possibility of survival of living organisms. In very brief, following are the importance of atmosphere.

Atmosphere is made up of several gases. These gases are important for the living world. Oxygen available in the atmosphere is the life of all animals including human beings for breath. Carbon dioxide gas helps in photosynthesis by plants which is food for many animals. Without food, they are unable to live. Photosynthesis is not possible without the humidity of the air and soils. Hence, availability of water is also very important and it is partly also found in the air in the form of vapour. The atmospheric vapour is distributed and redistributed all through the globe by hydrological cycle but not uniformly. Nitrogen is equally very vital for making proteins through nitrogen fixation to plants and to all animals. It is the building blocks for the growth of the body of all animals. Ozone is a protective layer of the atmosphere which traps harmful ultra-violet rays coming from the solar radiations. Its trapping in the ozonosphere ensures good health of all flora and fauna of the earth particularly in the higher latitudes. Carbon dioxide, methane, nitrous oxide, fluorinated gases, water vapour etc. are responsible for keeping the earth warm. Solar energy is reaching to the ground directly from the sun by short wave radiations. But when the earth radiates back the received energy to space, it is being trapped by greenhouse gases. They keep the earth liveable and maintain proper temperature. Without greenhouse effect, the average temperature would fall to minus 18^0C whereas at present the average temperature of the earth is 15^0C. The difference between the two is of 33^0C.

We are able to hear any sound because of the presence of air in the atmosphere. It behaves like a medium to transport the sound waves. Flying of aeroplane is possible because of air as it helps in floatation and marching forward the plane.

CONCLUSIONS

Our atmosphere is composed of several gases and other substances. The major gases are nitrogen, oxygen, argon and carbon dioxide. Some minor gases whose proportion is very low are methane, neon, helium, krypton, hydrogen etc. and some other substances are water vapour, dust particles and aerosols. Their percentage in making the whole of atmosphere is substantially variable. All of them are the constituent of the atmosphere and are included in its constitution.

The meaning of the structure is the arrangement of the different parts into one. Therefore, the structure of atmosphere is different layers varying with altitudes. It is primarily divided into two homosphere and heterosphere based on the homogeneity or the mixing of the air. Within homosphere, there are three layers – troposphere, stratosphere and mesosphere. The proportion of gases in these layers are almost uniform with height. All weather phenomena are occurring in the troposphere and temperature decreases with altitudes. The temperature keeps on increasing in the stratosphere because of absorption of solar radiation by ozone. Mesosphere witnesses the declining temperature which reaches to around minus 130^0C, colder than the Antarctic.

Within heterosphere, there are two layer – thermosphere and exosphere. In these layers, gases are rarefied and molecules have very wide gaps. They very light in weight and are having the stratification on the basis of their density. Relatively heavier gases are in the lower layer and lighter in the upper layers. Thermosphere contains the molecules of nitrogen and oxygen whereas the exosphere has the molecules of hydrogen and helium.

The atmosphere is very important to all living lives of the earth. It is possible only because of the atmosphere. The importance of oxygen, carbon dioxide, nitrogen, ozone water vapour immense for the survival of all kinds of life. The greenhouse gases are maintaining a good balance to keep the earth liveable.