A COMPREHENSIVE APPROACH TO

PHYSICAL GEOGRAPHY

FOR SECONDARY SCHOOLS

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PREFACE

The struggle for education is a universal aspect since people decipher and know the importance of education in the whole gamut of life dynamics. In Tanzania as in other countries all over the world, education is being emphasized more than ever before. The governments, non-governmental organizations, individuals and other international organizations are concentrating efforts and resources on the educational sector. The aim is to raise the vacillating quality of education and make it more viable to the country and its development at large. Some people are investing in the search for new knowledge while others are developing educational materials. This book aims at easing the students' burden by acting as a potent stimulus or dynamo in enhancing the learning and teaching process as well as raising the academic performance. It is comprised of Physical Geography dealt with in a very comprehensive manner so as to inculcate a wide and thoroughgoing spectrum of Geography knowledge among students for secondary schools and colleges.

Geographical aspects have been covered in detail to equip students with standard analytical tools for approaching different challenging problems in Physical Geography.

The topics have been presented systematically following the order of the Current Syllabus. It is anticipated that students and teachers will find it a useful and relevant resource to be used in the verge of promoting academic transactions in Geography and sustaining the general performance among students.

Additionally, adequate preparation has been made involving numerous references so as to facilitate and ease the learning and teaching process.

Above all, this book will enable students to thoroughly prepare themselves for their National Form Four and Six examinations and be able to tackle challenging questions with high confidence.

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November, 2014.

CHAPTER ONE

POSITION, BEHAVIOURS AND STRUCTURE OF THE EARTH

What is Earth?

The Earth is the third planet from our sun in our solar system (Mercury is the closest. then Venus, then Earth), and it is where humans and other living organisms live. The, Earth is approximately 93 million miles (150 million kilometers) from the sun. It orbits around the sun every 365 days, 5 hours, 46 minutes, 46 seconds. The Earth has an axial tilt of 23 degrees with a rotation period of 23.5 minutes. Its mass is approximately 1.317 x 10^{25} pounds (5.97 x 10^{24} kilograms). It has an equtdrial diameter of 7926 miles (12,755 km) and a polar diameter of 7900 miles (12,714 km). The Earth has one satellite call moon. A satellite is an Object that moves around a larger object. The Earth is a satellite because it moves around the sun. The moon is a satellite because moves around the Earth. The Earth and the moon are called “natural” satellite. This relationship is illustrated in figure 1.1 as follows:

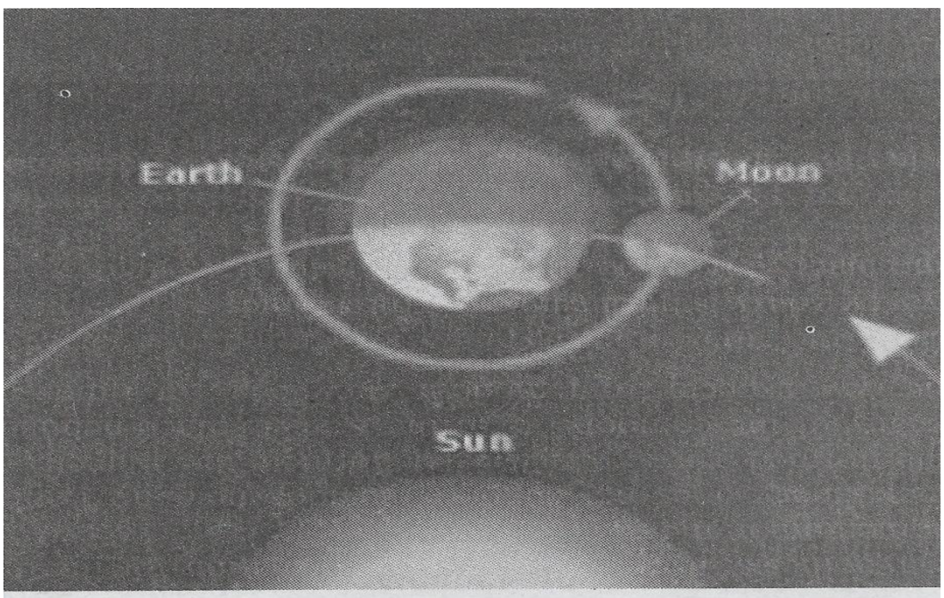

Figure 1.1: The Sun, the Earth and the Moon

The Earth is our home planet. Scientists think the Earth formed billions of years ago. It is estimated to be 4.5 billion to 5 billion years old, based on radioactive dating of lunar rocks and meteorites, which are thought to have formed at same time. Four planets in the solar system are bigger than Earth and the planets are smaller. The Earth is the only planet known to have lots of life has been found. People, animals and plants live on Earth: Some living things are very tiny while others may be very large.

What are Earth's Different Parts?

The Earth is made up of land, air, water and life. Mountains, valleys and flat places make up the land. The air is made of different gases. One of the gases is oxygen. Oceans, lakes, rivers, streams, rain, snow and ice are made of water. Each part of Earth connects to and works with the other parts. For example:

- Clouds in the air drop rain and snow on land.
- Water gives life to plants and animals.
- Volcanoes on land send gas and dust into the air.
- People breathe air and drink water.

The position of the Earth in the solar system is illustrated in figure 1.2 as follows:

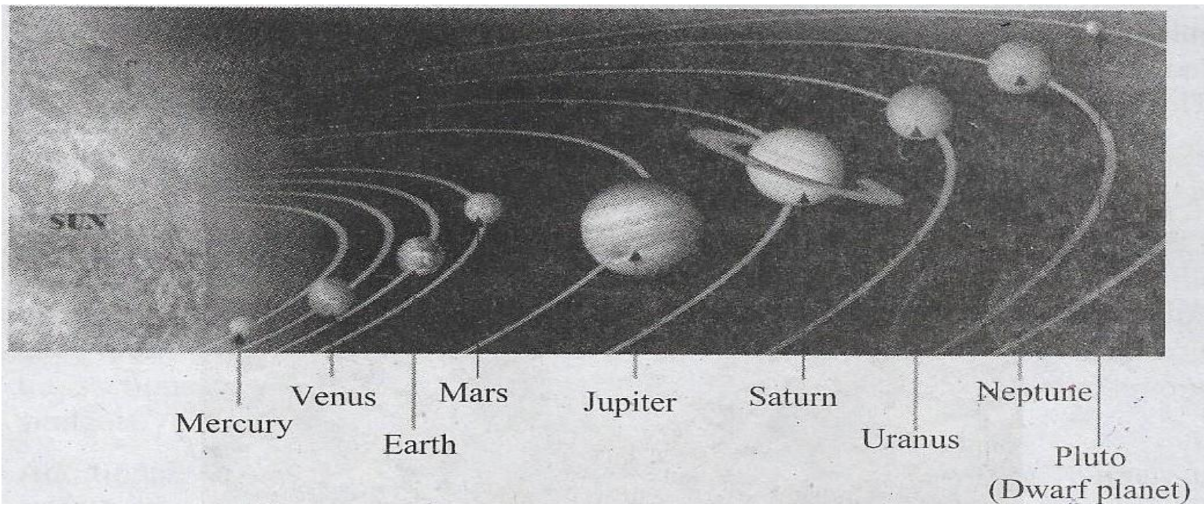

Figure 1.2: The position of the Earth in the solar system

Figure 1.2 indicates that the Earth occupies the third position from the Sun. It is preceded by Mercury and Venus.

Regarding the solar system indicated above, it has to be borne in mind that ever since the discovery of Pluto in 1930, children grew up learning about the nine planets of our solar system. That all changed starting in the late 1990s when astronomers began to argue about whether Pluto was a planet. In a highly controversial decision, the International Astronomical Union ultimately decided in 2006 to call Pluto a "dwarf planet," reducing the list of "real planets" in our solar system to eight. But many children (and adults) cling to the notion of nine planets. It can then be said that real planets are eight in the solar system in which the Earth belongs.

Characteristics of the planet Earth

The Earth like other planets has various characteristics as follows:

1. It sustains life of humans and other organisms. The ability to support life is attributed to its position. The Earth is the third planet from the Sun, with Mercury and Venus being closer. Its unique position gives the Earth a temperate climate, allowing the chemical reactions necessary to sustain life.
2. The Earth revolves around the sun: The Earth goes around the Sun in a counter-clockwise orbit, taking a year or about 365 days to make one revolution.
3. It rotates on its axis: The Earth spins or rotates on its axis in a counterclockwise motion, as viewed from above the North Pole. It makes one revolution in 24 hours. The spinning of the Earth on its axis is what causes the Sun to appear to move across the sky. The effect the apparent movement of the Sun is similar to looking out the window of a moving car, where things outside appear to be moving past you. The rotation leads to the occurrence of days and nights.
4. It is tilted due to the tilted axis: The Earth's axis also tilts with respect to thç Sun, causing the changes of the seasons. In summer, the Earth is tilted such that the Sun falls more directly, while in winter the Sun. looks lower in the horizon and the light comes at a glancing angle. The tilt of the Earth also causes, the summer days to be longer than the nights. 'In winter the days are shorter and there is less light to heat the ground. The tilting of the Earth's' axis is illustrated in figure 1.3 as follows:

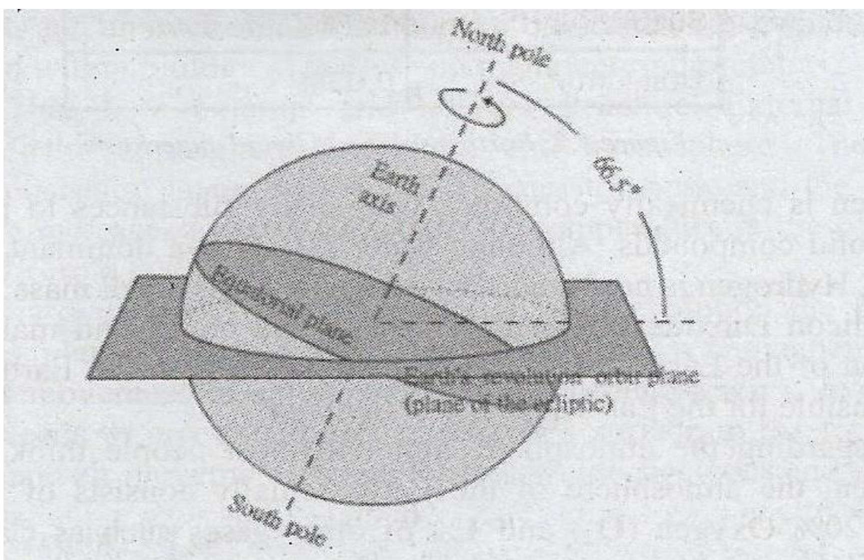

Figure 1.3: Tilted Earth's axis

The further north you go, the more the effect of the tilt of the Earth is apparent. Above the Arctic Circle, daylight can be seen for a full 24 hours in the summer or night can be 24 hours in the winter. That is why the area is called "the land of the midnight sun."

5. It has a spherical in shape: Just as the Sun and Moon appear as spheres, so too is the Earth spherical in shape. To people on Earth, the planet appears to be generally flat (not counting for hills and valleys), but in reality the surface of the Earth has a slight curve. This can be noticed when looking out on a large lake or the ocean and seeing a ship come up along the horizon. Its shape is actually slightly flattened at the poles.

6. Earth's composition: The composition of the Earth consists of the solid and liquid portion and the atmosphere or gaseous portion. The percentage composition of the Earth's solid and liquid materials (by mass) is depicted in figure 1.4 as follows:

Element	**Percentage**
Iron	34.6%
Oxygen	**29.5%**
Silicon	**15.2%**
Magnesium	**12.7%**
Nickel	***2.4%***
Sulfur	**1.9%**
Titanium	**0.05%**

Figure 1.4: Earth's solid and liquid materials

Oxygen is chemically combined with many substances to produce liquid and solid compounds. Although water **(H_2O)** is a dominant compound on Earth, Hydrogen is not listed above because of its small mass.

Silicon Dioxide **(SiO_2)** is sand, and that compound makes up a large portion of the Earth's mass. Much of the Iron is in the Earth's core and is responsible for the Earth's magnetic field.
Regarding the atmosphere, although most people think air is mainly

Oxygen, the atmosphere of the Earth actually consists of 79% Nitrogen (N_2), 20% Oxygen **(O_2)** and 1% of other gases such as Carbon Dioxide **(CO_2).**

7. Force fields: The Earth has two major force fields: gravity and magnetism. Gravity is the force at a distance that attracts objects of mass toward each other. The force of gravity from the Earth holds down our atmosphere, oceans and everything else. Regarding the magnetic field: The Earth is like a giant magnet with a magnetic pole near the North Pole and the opposite near the South Pole. The north pole of a magnet seeks the North Magnetic Pole. Through the ages, indications are that the poles switched directions. No one is sure why this happened. The rotation of the Earth and the fact that the core of the Earth is made of iron are major factors in creating the magnetic field. One thing the magnetic field does is to attract charged particles that have been emitted from the Sun. The focusing of these particles at the poles may help to prevent us from being harmed by the high energy particles. These particles cause the air in the upper atmosphere to glow. This is called the northern lights (aurora borealis) or southern lights (aurora australis).
8. Nature of the Earth's surface: The Earth's surface is irregular. The Earth's surface is characterised by mountains, hills, lowlands, valleys, plateaus, depressions and large basins. Valleys lead to formation of rivers while basins lead to formation of lakes and seas. The Earth's surface can also be divided into land and water masses. Water covers 71% of the Earth's surface and it is vital for all known forms of life. On Earth, 96.5% of the planet's water is found in seas and oceans, 1.7% in groundwater, 1.7% in glaciers and

the ice caps of Antarctica and Greenland, a small fraction in other large water bodies, and 0.00 1% in the air as vapour, clouds (formed of solid and liq.uid water particles suspended in air), and precipitation. Only 2.5% of the Earth's water is freshwater, and 98.8% of that water is in ice and groundwater. Less than 0.3% of all freshwater is in rivers, lakes, and the atmosphere, and an even smaller amount of the Earth's freshwater (0 003%) is contained within biological bodies and manufactured products.

9. The Earth has both external and internal structure. External structure consists of the atmosphere, biosphere and hydrosphere. The internal structure consists of layers which are: The crust, mantle and the core. The temperature increases towards the core. The temperature in the core ranges from 3,700°C to 6,000°C.
10. The Earth is dynamic: Apart from rotation and revolution the Earth also expetences plate tectonic and isostatic readjustment movements due to convection movement of upper mantle (the asthenosphere); hydrological cycle that leads to precipitation on the Earth's surface in the form of rain and snow; and air movements in the form of winds, cyclones and tornadoes

The Genesis (Origin) Of the Earth

The Earth is one of the planets in the solar system and it is estimated to be 4.5 to 5 billion years old, based on radioactive dating of lunar rocks and meteorites., which are thought to have been formed at the same time. When discussing the origin of the earth, one cannot avoid discussing the origin (genesis) of the solar system or the universe. The origin of the earth, just like that of the solar system or the universe, continues to be controversial. The controversy over the genesis (origin) of the earth, as well as that of the solar system, has led to the existence of various theories (hypotheses) that explain how the solar system was formed, and hence the formation of the planet 'earth'.

These theories (hypotheses) that explain the origin of the solar system are referred to as ***cosmological theories (hypotheses).*** Cosmological theories (hypotheses) are many, but this book deals with the prominent ones which include: creation theory (hypothesis), nebular theories (hypotheses), encounter theories (hypotheses) and big bang hypothesis. These theories are controversial on the basis of the perspectives or speculations of the proponents who propounded them. The theories are explained in detail as follows:

Creation Theory

This theory is also called biblical or religious theory. Creation theory maintains that, in the beginning, God created the heavens and the earth. And God said, 'let there be light in the expanse of the sky to separate the day from the night, and let them serve as signs to mark seasons and days and the years, and let them be lights in the expanse of the sky to give light to the earth'. And it was so. God made two great lights — the greater light (the sun) to govern the day and the lesser light (the moon) to govern the night. He also made the stars. God set them in the expanse of the sky to give light on the earth, to govern the day and the night, and to separate light from darkness. And God saw that it was' good. This text is found in Genesis, the first book of the bible, in the first chapter. Archbishop Usher was among the proponents of this theory.

Nebular Hypotheses (Theories)

There were individuals who developed theories that contradict the creation theory. They based their arguments on the existence of the cloud of gases called nebula, in the sky. Theories that constitute the nebular hypotheses include Kant-Laplace nebular hypothesis (theory) and the protoplanet hypothesis (theory). These are further explained in detail as follows:

Kant-Laplace Nebular Hypothesis

The idea of nebular hypothesis was first put forward in general terms by Immanuel Kant, in 1755. Kant proposed that a nebula, which is a huge cloud of dust and gas, was pulled together by gravity and cooling such that it collapsed into a flat, rotating disk. The disk eventually coalesced into the sun and planets. Kant also stated that because a similar process occurs around other stars, our solar system is not alone in the universe.

Pierre Laplace expanded on Kant’s theory, in 1776, such that it came to be known as the Kant-Laplace nebular hypothesis. Laplace proposed that the planets were formed by the rings of the matter split off a rotating nebula by centrifugal force. After the matter split off, it coalesced into a planet. The process repeated itself resulting in a planet each time until all nine planets were formed. The matter left over was the Sun. The theory is generally called Kant- Laplace theory since the arguments espoused in the theory were advanced by them.

Kant-Laplace hypothesis (theory) succeeded in using a flat, rotating nebula as the solar system is origin to explain why all planets orbit in nearly the same plane and in the same direction. The theory, however, contained a few problems. One of the weaknesses is that, the possibility of the rings forming spherical planets is highly doubted, and the theory never provided a clear explanation.

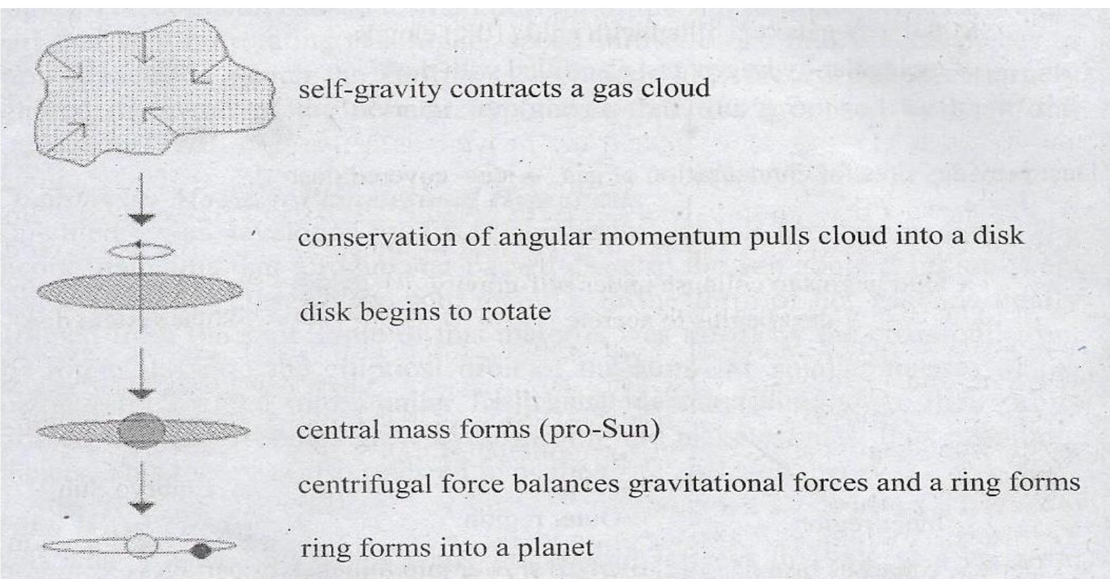

Figure 1 5 Kant Laplace Nebula, hypothesis

Protoplanet (dust cloud) hypothesis

This was an advanced version of the nebula hypothesis (theory) developed by Carl Friedrich von Weizsacker, Gerald P. Kuiper and Harold C. Urey between 1940 and 1955. It can also be referred to as, *condensation or nebular contraction theory.*

According to protoplanet hypothesis (theory), the solar system was formed from a slowly rotating cloud of dust and gas (nebula) that contracted and started rotating faster in its outer parts. As the clouds cooled, the dust particles began sticking together (accreting) into billions of planetesimals (spherical objects) with diameters of about 10 meters. The planetesimals then collided to form protoplanets that became today's planets, all moving in the same direction. The slowly rotating central part of the cloud condensed and formed the protosun and then the sun. The sun's central temperature rose as gravity further compressed the material.

Despite the protoplanet theory's success in correcting the problems with the Kant-Laplace hypothesis, it did not provide explanation for the distribution of the angular momentum in the solar system.

The protoplanet theory does not support the idea held by Laplace, that the rotating nebula formed rings which later formed the planets. However, it incorporates many of the components of the Kant-Laplace nebular hypothesis, but adds some new aspects from modern knowledge of fluids and states of matter.

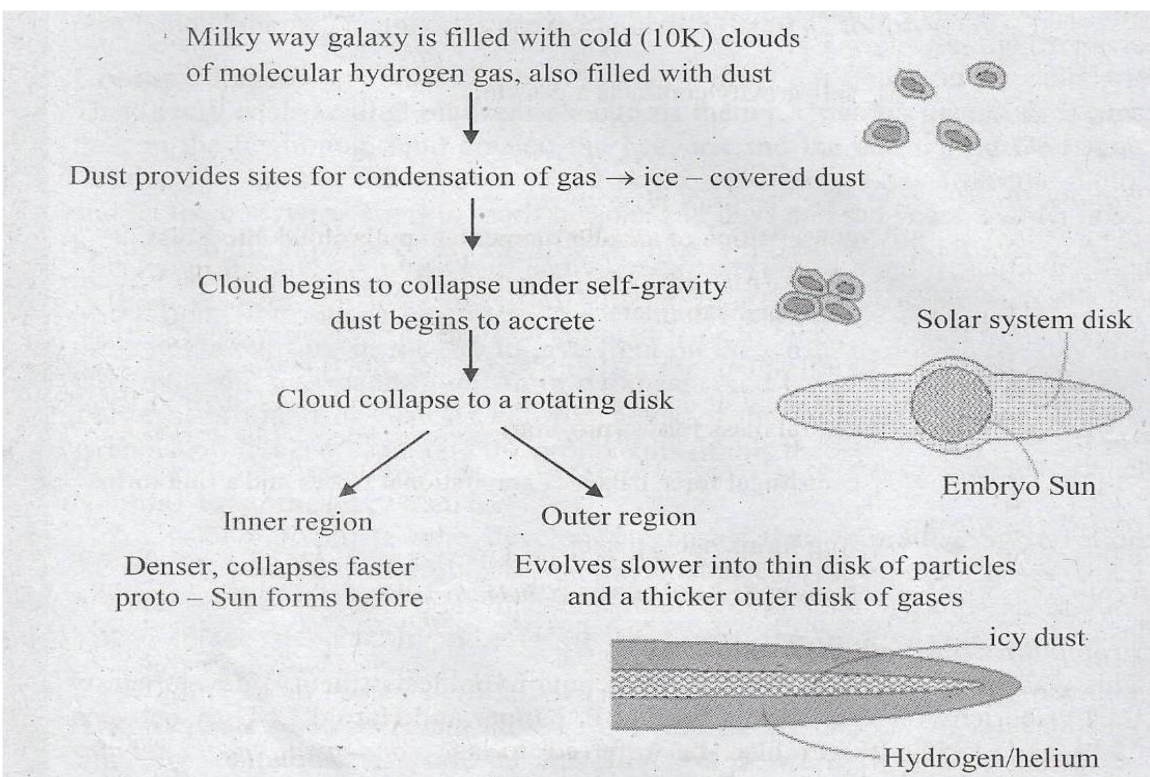

Figure 1.6: Protoplanet hypothesis

Encounter Hypotheses (Theories)

Encounter hypotheses entail various theories, some of which are based on the assumption that there was a collision between the sun and another heavenly body, leading to the formation of planets while others, espouse the assumption that the passage of a rogue star close to the sun led to occurrence of disturbances that eventually caused the formation of the planets. These theories contradict the assumption that there existed a cloud of dust and gases in the sky.

They assume that the sun and the stars were already in existence. Encounter hypotheses are sometimes called *collision theories, catastrophic theories or cataclysmic theories.* Examples of the encounter hypotheses (theories) are cometary collision by Buffon (1749), Chamberlin-Moulton planetesimal hypothesis and the tidal wave theory. The theories can be explained in detail as follows:

Cometary Collision Hypothesis

This hypothesis (theory) was propounded by Buffon (1749). According to the theory, there once occurred a catastrophic collision between the sun and the comet. The collision caused a small portion of the sun to break off. The broken part that kept on rotating at a higher speed further broke into several pieces to form planets, in which the earth was included. This theory was later largely ignored in favour of the nebular hypothesis that was proposed by Kant and Laplace in 1755.

Chamberlin-Moulton Planetesimal Hypothesis

This theory was developed by T.C. Chamberlin and F.R Moulton in 1905. The theory maintains that a rogue star passed close to the sun about *5* billion years ago. On passing close to the sun, material in the form of hot gas was tidally stripped from the sun. Some of this material was thrust by the cross-pull from the rogue star into the elliptical orbit of the sun. The smaller masses of the material fragmented into smaller lumps called planetesimals. As their orbits crossed, the larger bodies grew by absorbing the planetesimals, thus becoming planets. This theory is also referred to as the *near-collision* theory.

Tidal Wave Theory

This was proposed by James Jeans and Harold Jeffreys in 1918, as a variation and improvement of the planetesimal *(near-collision)* concept: it suggests that a huge tidal wave, raised on the sun by a passing star, was drawn into a long filament and became detached from the principal mass. As the stream of gaseous material condensed, it become separated into masses of various sizes, which further, by condensation, took form of the planets. Planetesimal (near- collision) and tidal wave theories can also be categorized under the group of capture theories due to the nature in which the materials were captured from the sun by a passing star. Unlike the cometary collision theory, the planetesimal and tidal theories do not state specifically what type of star was involved in the collision.

Weaknesses of encounter theories

There are various weaknesses of encounter theories which include:

First, the theories assume that that the sun existed before the formation of planets, and do not explain how the sun was formed.

Second, the encounters between the stars are extremely rare; the theory does not state why such an encounter does not happen today. What stopped such encounters? Despite the weaknesses, encounter theories have the advantage of explaining why the planets revolve in the same direction (from the encounter geometry), and also provide an explanation as to why the inner worlds are denser than the outer worlds.

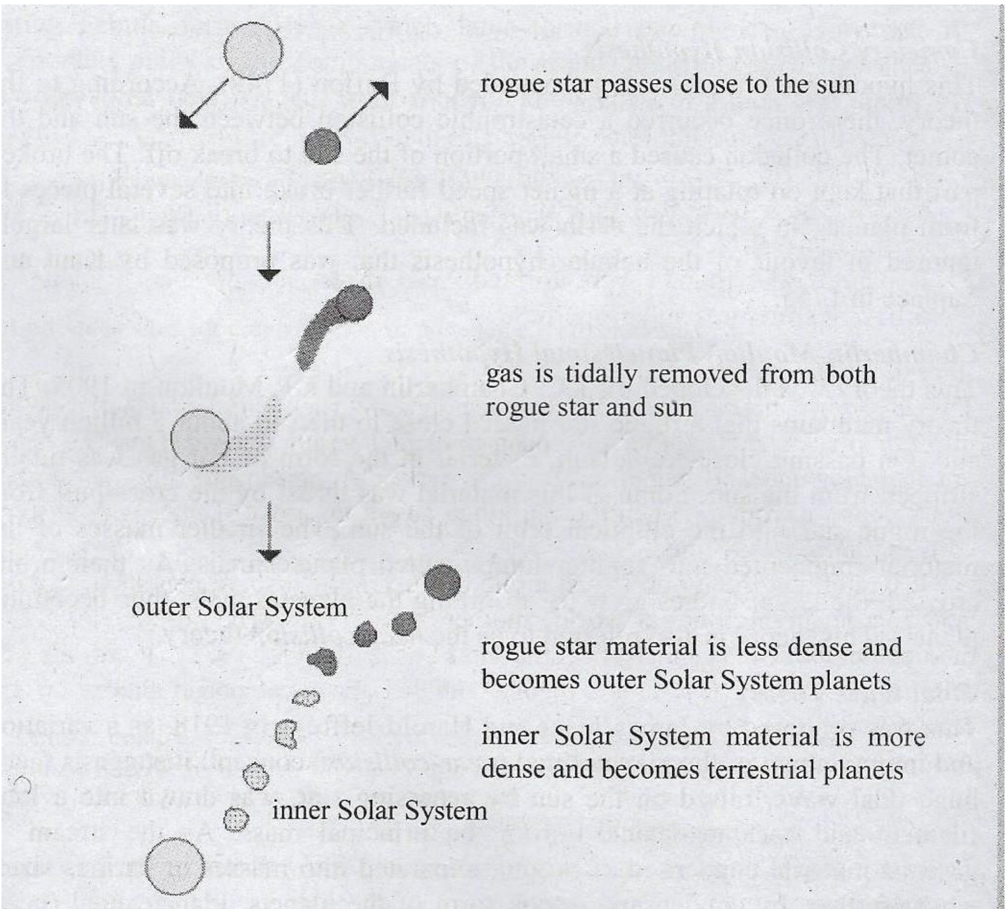

Figure 1.7: Encounter hypothesis

Other theories of the origin of the Earth

Apart from the creation theory, nebular theories, and encounter theories, other theories that, have been discussed in this book are the fission theory, accretion theory, gas cloud theory and stellar collision theory. These are elaborated as follows:

Fission Theory

The “fission theory” says that our sun burst one day, and all our planets came from it. Then the moons shot out from each planet, stopped, turned sideways and began circling around the planets they came out of. Our moon is said to have emerged from an explosion in the Pacific Ocean. George Darwin is one of the proponents of this theory.

There are several problems associated with this theory, they include:

1. While the moon was moving outwards from the earth, gravity would have pulverized it into rings.
2. The rocks in the moon are somewhat different in composition from the material on the earth.
3. Immense outward explosions would have hurled material straight out into space; they would not have circled and then form carefully balanced orbits.
4. If thrown off by the earth, the moon should circle our world over the equator, but, instead of this, it orbits our planet at a tilt of 18-28° to the earth’s equator,
5. If planets and moons were formed from the sun, why then are they of different structures and properties?

Accretion Theory

This theory maintains that a pile of space dust and rock chunks pushed together into our planet, and another pile pushed itself into our moon. Then the moon got close enough and began circling the earth. “According to this idea, a dust cloud began to rotate. When the mass had swept up most of the material in an eddy, a planet was formed.

It is said that the moon is just a pile of dust, and “just happened” to wander near and began circling our world, another “pile of dust. The proponents of this theory include: M. Bishop, B. Sutherland and P. Lewis (1981). It can also be referred to as the dust cloud theory, the nebular contraction theory or the condensation theory.

Accretion theory has been criticized on various grounds as follows:

1. It does not tell the origin of the dust and the loose chunks of rocks. Where did the dust and the chunks of rocks come from?
2. Loose gravel in outer space would not have pushed itself together; it would have pushed apart.
3. Two huge spheres the earth and the moon, so close to each other, would fly apart or, being so close to each other, would soon crash. They would not V endlessly circle one another, neither colliding nor separating.

Gas Cloud Theory

The theory states that gas clouds were captured by our sun. But instead of being drawn into it, they began whirling and pushing themselves into planets and moons. According to the theory, gas formed into dust grains, and these glued together somehow and built up into fist-sized chunks. These pieces continued to grow until they became planets and moons. Gas cloud theory has been criticized as follows:

1. Harwit calculated that it would be impossible for the gas and dust to stick together in outer space and before any condensation of gas and dust could occur, it all would separate. This means that gas does not lump together; it spreads outwards.
2. If these planets and moons did adhere in that manner, they would not orbit one another, nor would they, all together, circle the sun.
3. The theory does not account for the systematic orbiting of the moons and H the planets. What led to the systematic orbiting of planets and moons in the solar system?

Stellar Collision Theory

The "collision theory" of the origin of our entire solar system suggests that our planets, moons and sun all spun off from a collision between stars. Stellar collision simply means collision between stars. The assumption is that, at the beginning, there was no sun but stars. Hence, when these stars collided, the sun was formed alongside other heavenly bodies.

Like other theories, stellar collision theory has been criticized on the basis of the following weaknesses:

1. The origin of the stars has not been explained. Where did the stars come from?
2. As collision hurls materials outwards the debris would continually travel outwards forever. What stopped them?
3. If the pieces were drawn together by gravity, they would have smashed into each other; they would not mutually orbit.
4. Each planet and moon in our solar system has unique structures and properties. How could each one be different if all of them came from a common stellar collision?

Conclusion about the cosmological theories

It is important to be aware that there is no one theory for the origin and subsequent evolution of the Solar System that is generally accepted. All theories represent models which ft some of the facts observed today, but not all. I-fence, discussions on the origin of the earth/solar system continue to be controversial.

When examined analytically, the cosmological theories which have already been covered in this topic can also be categorized into two groups. The first group contains theories which assume that the planets and the sun were formed at the same time; these, are referred to as ***co-eval*** theories. Nebular hypotheses and the stellar collision theory are grouped under this category. The second group contains theories which assume that the planets were formed when the sun was already in existence; these are referred to as ***non-co-eval*** theories. Most of the encounter or collision (planetesimal) theories fall under this category.

The Big Bang Theory

It has to be borne in mind that the origin of the Earth has much in common with the origin of the solar system. In other words, the forces that led to the existence of the solar system are the same that led to the existence of the Earth since when the solar system was being formed planets including the Earth were formed. But one also has to remember that the solar system is part of the universe. The universe was created first and then the solar system came into existence later. The question is how was the universe formed?

The big bang theory is one of the theories that explain how the universe came into existence. The origin of this theory can be credited to a Belgian Astronomer Lemaitre Georges and an American scientist, Edwin Hubble who put forward the theory in 1927.

According to this theory, right from the beginning there was nothing, and between 10 to 20 billion years ago, the entire universe was compressed into the confines of atomic nucleus. From unimaginable dense and extremely hot state of being, it exploded with trillions of degrees in temperature, creating time and space itself. Later, during the next five billion years, clumps of gas began condensing leading to the formation of galaxies, in which stars were born. Today, billions of years after the Big Bang, the universe is still expanding and hence there has been more and more distance between clusters of galaxies.

Arguments against the Big Bang Theory

There are several critiques which have been levelled against the Big Bang theory. They include: First, According to the Big Bang theory, all galaxies should have the same age, but research shows that there are some relatively young galaxies near ours. Second, some galaxies have been discovered to be older than the universe itself. Third, it is doubtable about how “nothing” can explode to form the universe and the Earth inclusive and how it appears today.

Conclusion on the Big Bang theory

The Big Bang theory provides a viable solution to one of the most pressing questions of all time concerning the origin of the universe. It is important to understand, however, that the theory itself is constantly being revised. As more observations are made and more research conducted, the Big Bang theory becomes more complete, and our knowledge about the origin of the universe more substantial.

Earth as a system

Generally, the Earth can be said to be a system. There are five parts of the Earth system. Each part has its own collection of materials and processes. However, the parts of the Earth system do not operate on their own. They all interact with other parts in many ways. The five parts or components of the Earth’s system are:

- The atmosphere extends up from the Earth surface for several hundred kilometres. The lowest part is home to clouds and weather.

- The biosphere is all living things, from single-celled bacteria to plants and animals.
- The geosphere includes all minerals, rocks, molten rock, sediments, and soils (although there are important living components to soils as well).
- The hydrosphere includes the ocean, rivers, lakes, streams, groundwater, water vapour, and even puddles.
- The cryosphere is the frozen part of the Earth system and includes snow, glaciers, and sea ice.

Interaction of Earth's parts above takes place in the grand natural cycles through which vital elements like carbon, nitrogen, phosphorus and sulphur circulate around the planet, the movement of water between sea, sky, rivers and ice; the imperceptibly slow events deep beneath our feet that create and destroy continents and oceans.

Living things are part of the system too. For example, ocean plankton absorbs carbon dioxide from the air to make their shells, after death their bodies sink to the seabed, where that carbon is locked up for millennia in layers of sediment that are slowly compressed to make limestone.

Humans are no exception. We are not an outside force disturbing the natural order of things — we are an integral part of the Earth system ourselves. But as our societies have grown, the impact of our actions has increased too; we are now among the main causes of environmental change. For example, the amount of greenhouse gases in the atmosphere varies naturally, but levels of carbon dioxide and methane in the atmosphere are now higher than at any time in the last one million years, possibly 15 million. This is due to industrial activities and large scale commercial cultivation. Our great dams are trapping gigatonnes of sediment; our farms are draining aquifers. In many places this is happening faster than they can refill; our appetite for land is clearing enormous swathes of forest leading to deforestation and later desertification.

The Earth's atmosphere

The atmosphere is a thin layer of gases held to the Earth by the gravitational attraction. It consists of different elements and layers, which can be known by variable changes and density due to altitude.

The structure of the atmosphere

The atmosphere is divided into layers based on temperature change with altitude. The layers are troposphere, stratosphere, mesosphere, thermosphere, and ***exosphexe.***

The troposphere

It is nearest to the Earth. It consists of *75%* gases, dust and water vapour. It varies in thickness from 8 km at the poles to about 17 km at the equator. Weather elements occur in this zone and temperature decreases with an increase in altitude at the rate of 0.6°C per 100m (3.3°F per 1000 ft) rise. This rate of change is referred to as the *environmental (or static) lapse rate.* The troposphere is a very important layer in supporting the life of organisms. 'For example, the formation of rainfall in this layer leads to the growth of plants, which are used as food by animals and human beings. At about 11 km above the Earth, there is the tropopause; the zone of separation between the troposphere and the stratosphere.

The stratosphere

It is the second layer extending from 17 km to 50km above the Earth's surface. In the lower parts of this layer, temperatures are constant, cloudless, thin air, no dust, smoke or vapour. However, at 50 km the temperature rises from —50°C to about 0°C. (The rise in temperature is called *temperature inversion).* The stratosphere contains the ozone layer with a maximum concentration at.25 km. This contributes to the rise in temperature in this layer since it absorbs incoming ultraviolet radiation from the sun. Therefore, the ozone gas filters off the ultra violet rays from the sun, which could otherwise have adverse effects on the surface, in case there was no protection. The troposphere and stratosphere together form the *lower atmosphere.*

The mesosphere

It is the third layer, which is separated from the stratosphere by a zone of discontinuity, called the *stratopause.* It extends between 80 — 90 km (50 — 55 miles). It is the coldest zone of the atmosphere. Temperatures decrease to — 90 or — I 00—°C at the top of the mesospere. It also experiences the strongest winds nearly 3000 km/hr).

The thermosphere

It extends from 80 km and more into space. It is separated from the mesosphere by a zone of discontinuity called the *mesopause.* The temperature in the thermosphere increases rapidly with altitude to 1500°C due to absorption of solar energy by the atomic oxygen and ionization. The increase in temperature with altitude is called *temperature inversion.* It has another layer, which has electrically charged particles of ions and free electrons, which reflect radio short waves. This layer is called the *ionosphere.* It is so important in the wireless communication. The ionosphere extends from about 8400 km up.

The exosphere

It is beyond 965km reaching the universe to the interplanetary space. It is extremely dark. It has not been greatly investigated.

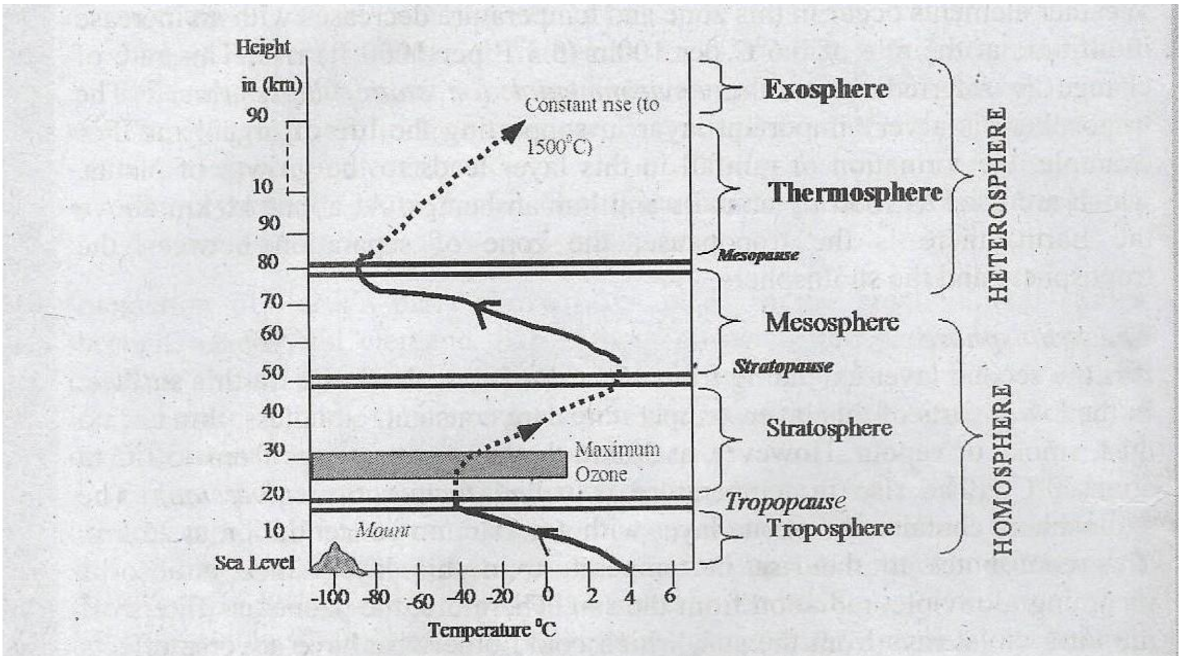

Figure 1.8: The structure of the atmosphere

What is Ionosphere?

The ionosphere is a region of the upper atmosphere that includes the thermosphere and parts of the mesosphere and exosphere. It is distinguished because it is ionized by solar radiation. It plays an important part in atmospheric electricity and forms the inner edge of the magnetosphere. It has practical Importance because, among other functions, it influences radio propagation to distant places on the Earth.

The ionosphere begins at a height of about 50 km (30 miles) above the surface, but it is most distinct and important above 80 km (50 miles). It extends as far as 600 km. In the upper regions of the ionosphere, beginning several hundred kilometres above Earth’s surface and extending tens of thousands of kilometres into the space is the magnetosphere, a region where the behaviour of charged particles is strongly affected by the magnetic fields of Earth and the Sun. It is in the lower part of the magnetosphere that overlaps with the ionosphere that the spectacular displays of the aurora borealis and aurora australis take place. The magnetosphere also contains the Van Allen radiation belt where highly energized protons and electrons travel back and forth between the poles of the Earth’s magnetic field. The location of the ionosphere is illustrated in figure 1.9 as follows;

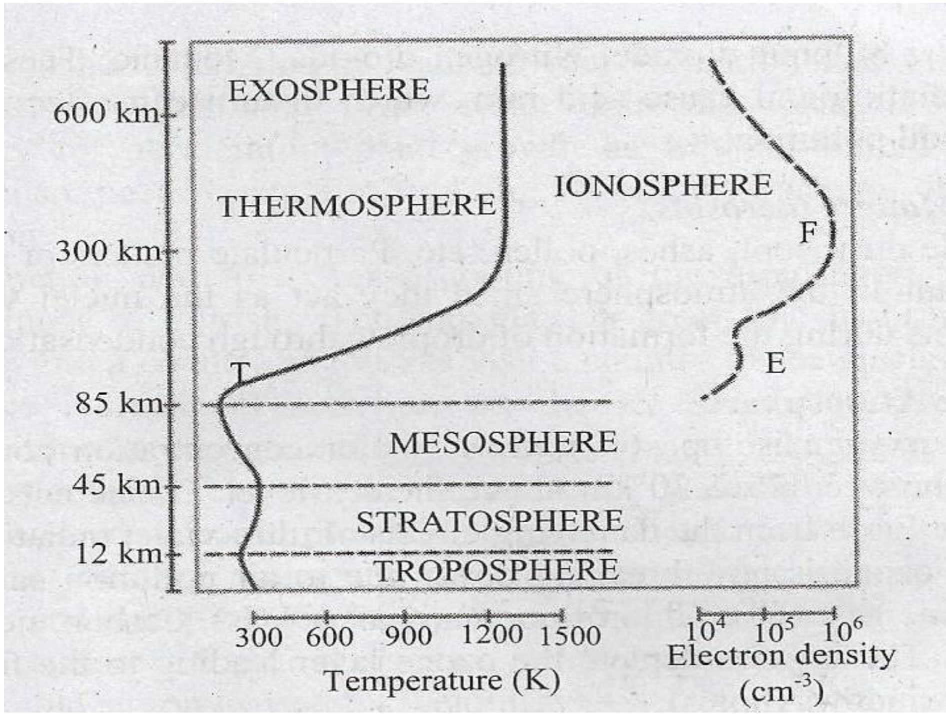

Figure 1.9: Location of the ionosphere

Composition of the Atmosphere

It is now known, as a result of space research, that the atmosphere can be divided into two major parts on the basis of chemical composition. The two parts are homosphere and heterosphere. Homosphere is the lower part extending to a height of about 80 - 90 km (50 to 55 miles) to the top of the mesosphere. It is called the homosphere because of its constant chemical composition. Heterosphere is the part above the homosphere. Heterosphere consists of a series of concentric layers, in terms of molecular nitrogen, oxygen, helium and hydrogen. It does not have a constant chemical composition. Though interesting, the heterosphere obviously has little significance to the meteorologist. Generally, the atmosphere is composed of various constituents, both abiotic and biotic. Abiotic components constitute non-living things or objects like gaseous and particulate matters while biotic components entail living organisms both fauna and flora.

Abiotic Components of the Atmosphere

Abiotic components of the atmosphere are gases and particulate matters as explained below.

Gaseous components

1. *Permanent (Fixed) gases:* That is Nitrogen (78%) and Oxygen (21%).
2. *Variable gases:* Water vapour (0.2-4.0%), Carbon dioxide (0.3%), Ozone (0.00006%).
3. *Inert gases:* Argon (0.93%), helium, Neon, Crypton.
4. *Pollutants:* Sulphur dioxide, Nitrogen dioxide, Methane. These pollutants affect radiation and cause acid rain, which in turn can affect the soil, by causing soil pollution.

Particulate Matters (aerosols)

These include dust, soot, ashes, pollen, etc. Particulate matters or aerosols are v.ery important in the atmosphere since they act as the nuclei where water vapour collects during the formation of droplets through condensation.

Ozone in the Atmosphere

Ozone is an oxygen isotope (03) whose major concentration zone is in the stratosphere between 25 - 30 km above the sea level. Ozone acts as a shield protecting the Earth from the damaging effects of ultra-violet radiation from the sun. But the ozone is now breaking down due to air pollution caused by the impact of some gases like Chlorofluorocarbons (CFCs), Carbon monoxide and methane gas. These gases deplete the ozone layer leading to the formation of atmospheric windows (holes).

Effects of Ozone Layer Depletion

1. Melting of ice, due to the increase in temperature. The temperature rises because of the strong rays from the sun that reach the surface.
2. Rising of the sea level because of the melting of ice on the surface. The recent investigations show that the Antarctic ice sheet is getting thinner and thinner due to the gradual melting of ice, as a result of the impact of the increase in temperature. This has been associated with the creation of atmospheric window over Antarctica, which allows the penetration of Ultra-violet rays.
3. Ultra-violet rays destroy skin tissues leading to the occurrence of skin cancer, as well as the damaging the skin colouring pigment (melanin).
4. Death and disappearance of some plant and animal species because of the adverse atmospheric changes caused by the impact of ultra-violet radiation.

Importance and impact of the atmosphere on life

Importance of the atmosphere on life

The atmosphere is important in supporting the life of living organisms as follows:

1. It has oxygen which is inhaled by living organisms. Oxygen is important in burning food in human beings and animals to generate energy. Human beings and animals breathe oxygen. The atmosphere also provides carbon dioxide needed for metabolism to take place in plants during photosynthesis.
2. The atmosphere also provides light needed for photosynthesis in plants. Without light photosynthesis cannot take place and plants die.
3. The atmospheric circulation leads to rain formation and other forms of precipitation which later bring water onto the surface. The water is necessary for accelerating plant growth as well as animal use. Human beings also need water for drinking, cooking, washing, irrigation and recreation.

4. Ice formation due to extreme cooling of the atmosphere leads to the development of tourism. Tourism plays a great role in bringing foreign currency into a country as tourists visit a country to see glacial features and undertake recreational activities on the ice sheets. In Switzerland for example tourists engage in skiing, tobogganing, and skating on ice cover.
5. Precipitation also leads to the formation of waterfalls which are used in generating hydroelectric power. The hydroelectric power in turn is used in industries, running transport vessels like electric trains, heating and cooking, and operating cooling systems (air conditioners) in houses.
6. The atmosphere is a natural resource. It has gases that are used in industries. For example, argon is used for welding.
7. The atmosphere through the ozone layer protects living organisms from the dangerous radiations from the sun. These radiations are ultra-violet rays. These rays are dangerous as they can cause skin cancer on human beings and the general rise of temperature on the Earth's surface.
8. The atmosphere acts as a security blanket as it keeps heat. This prevents extreme cooling of the air that could lead to problems in life. If there is extreme cooling soil can be frozen leading to problems in plant growth and hence there cannot be crop production.
9. Clouds in the atmosphere reflect insolation back into space preventing occurrence of high temperature on the Earth's surface. They also prevent excessive evaporation that can lead to drying of water bodies (desiccation).
10. The upper layers of the atmosphere help in preventing some meteorites from reaching the surface when falling towards, the Earth's surface. The layers burn them out before reaching the surface. If it were not for this protection, meteorites could reach the surface and cause destruction to life and property.
11. The atmosphere helps birds and insects fly into the air and move from one place to another. Without air they could not fly. Their movements also assist in plant pollination as well as seeds dispersal.
12. Air movement also enables the airplanes to fly into the sky. Without air no airplane could fly into the sky and hence interaction among people in the world could be minimised.
13. The atmosphere transmits human sound which makes hearing possible. This means that the atmosphere facilitates communication between and among people
14. The ionosphere enhances propagation of radio waves to distant places. This helps people in distant places to get news from the radio stations and even know what is taking place in the world.
15. Dissipates the smoke and noxious gases released as a result of natural processes and human activities.
16. Wind movement is also important in rainfall distribution by moving the clouds, pollination, and driving the turbines to pump water and generate electricity. Apart from rainfall distribution, wind movement also plays a great role in heat balance. It helps in dispersing the heat from the equatorial region to polar areas.

Negative impact of the atmosphere on life

Apart from being important to life, the atmosphere has negative impacts as follows:

1. Storms caused by violent air circulation leads to destruction of houses and hindrances in air transport. Storms also lead to destruction of crops in farms and occurrence of floods along the coastal areas. The city of New Orleans, USA, for example was badly by a hurricane Katrina in 2005. About 80% of the city was flooded to depths of up to 6 metres. Figure 1.10 depicts areas affected by hurricane Katrina in New Orleans.

Figure 1.10: Areas affected by Hurricane Kagrina in New Orleans in 2005

2. Pollution of the atmosphere leads to occurrence of diseases like bronchitis and skin itching. Other effects of the atmospheric pollution include occurrence of acidic rainfall that destroys the soil and crops in farms, visual obscurity leading to problems movement of vehicles and sometimes accidents, and bad smell which make people live in discomfort.
3. Scarcity of water vapour in the atmosphere leads to drought which in turn causes famine and loss of vegetation on the Earth's surface.
4. Extreme cold conditions lead to soil freezing, human discomfort, frost that affects crops and migration of animals and birds. Soil freezing affects agricultural activities. This is common in tundra or Polar Regions where there is permafrost.
5. Mist and fog hinder effective car movements and sometimes can lead to car accidents leading to loss of people's life. Effect of mist and fog on car movement can be illustrated as follows:

Figure 1:11: Cars moving in misty conditions

6. Electric charges produced during the thunderstorm formation leads to destruction of property and death of people and animals. In Tanzania, fatal thunderstorms are common in Iringa especially in Mufindi, Rukwa region, Katavi region, Kigoma region and central parts like Tabora and Dodoma.
7. Too much rainfall leads to soil erosion and floods. These destroy soil vegetation and cause death of people and animals.