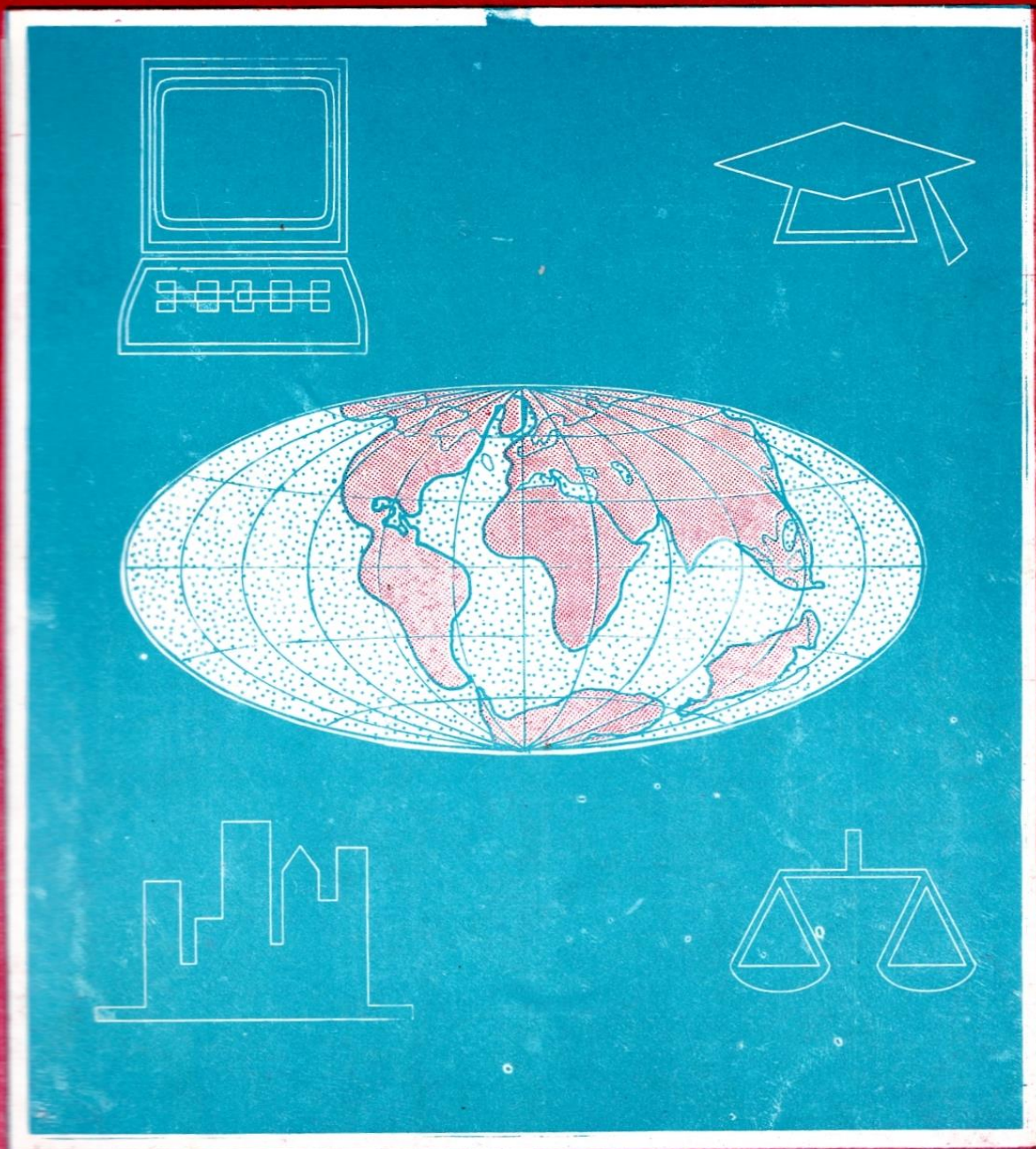


# TECHNOLOGY, SCIENCE AND ENVIRONMENT; A CURRENT OVERVIEW.



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## **Chapter Eight**

### **The Human Cosmic Environment**

**Inyang - Abia, M. E.**

#### **Introduction**

The rapid increase in scientific thinking and practice, products and processes and in technological growth and development have jointly sharpened the focus of attention on man and the environment. This is essentially so because without the environment there can neither be human beings nor development of any sort. An understanding of the human cosmic environment can therefore equip us better to more effectively relate among ourselves, and with different aspects of the environment. It can enhance our interaction with the various environmental components too. This can lead to a more sustainable approach to the use of the environment.

Understanding the human cosmic environment involved indepth study of the structure and functions of the universal environment. This chapter cannot cover all that. Consequently focus will be on man in relation to the solar system.

#### **The Universe**

This refers to all the space and its contents. It is believed to be between ten and twenty billion years old. The space of the universe is dotted with galaxies. It is believed to be expanding because the galaxies are observed to be continuously moving apart from each other at a rate which increases with their distance apart. Cosmology, the study of the universe, is the main source of information in this direction.

#### **The Galaxies**

These are congregations of billions of stars held together by the force of gravity. At least three types of galaxies can be identified.

**Spiral Galaxies :** These are flat-shaped galaxies with bulging centres made up of old stars surrounded by a disc of young stars arranged in about three spiral arms. The Milky Way, otherwise called "The Galaxy" is one good example of this. It is within the Milky Way that the solar system is found. Many types of spiral galaxies exist. Those which interest us are called the Barred galaxies. They are made up of spiral arms and a straight bar of stars across their centre. At the ends of the bar there are spiral arms which contain gas and dust necessary for the continuous formation of new stars. That means as old stars wane away, new ones are "born" within the spiral arms of the galaxy.

**Elliptical Galaxies:** These have been observed to contain billions and trillions of old stars and very little gas. They are also usually quite massive in size compared with the other galaxies.

**Irregular Galaxies:** These cannot be classified because they have irregular shapes and sizes and are completely different from each other.

#### **The Milky Way/The Galaxy**

This can be observed at clear nights as a faint band of light that crosses the sky. It is made up of about one hundred billion stars mostly located at the spiral arms. The term Milky Way is also used to refer to our Galaxy. The Milky Way



is a spiral galaxy with a diameter of about 1,000,000 light years. Our sun is in one of its spiral arms, about **twenty-five thousand** light years from the nucleus of the Milky Way. The solar system is therefore one tiny member of the Milky Way (the galaxy) which in turn is only one of the billions of galaxies that make up the universe.

## **The Sun**

The sun is a very hot bright star that spins on its axis once in twenty five days. It is at the centre of the solar system. It constitutes ninety-nine per cent of the mass of the solar system. Its diameter is about 1,392,000 km (865000 miles). It has a surface temperature of about 6,000 k (about 5729°C) and 15,000.000 k at centre. Kelvin scale (k) has absolute zero; 0°C = 273k, 100°C = 373 k.

The sun is made up of about 70% hydrogen and about 30% helium. The other elements are less than 1%. It generates energy by nuclear fusion reactions that turn hydrogen into helium at its centre. The sun is about 4.7 billion years old which means it is about 100 million years older than the solar system. According to Century Hutchinson (1989) it has a life expectancy of 10 billion years at which end it expands to become a "red giant" - a large bright star with a cool surface.

## **The Solar System**

Within our galaxy, the Milky Way, there are many systems. The solar system which is ruled by the sun is just one of such systems. The sun and its family members make up the solar system. Members of the Sun's family include the nine planets and their moons (the satellites), asteroids, comets, meteors and all other objects which revolve around it under the influence of the gravitational force (see figure 8.1)

All these members, except a few comets, orbit around the sun anti-clockwise, that is from west to east, as observed from the Pole Star. The solar system is popularly thought to have originated from a cloud of gas and dust.

## **Members of the Solar System**

The solar system is only one of the systems within the Milky Way or the Galaxy. The gravitational force of the sun governs the solar system. The sun, the nine planets, the asteroids, comets, satellites and meteors, etc make up this system.

### **a) The Major Planets**

Nine major planets have been discovered. They are as shown on fig. 8.1. Each planet moves on its own orbit except Pluto which twice intersects the orbit of Neptune. These planets are the major celestial bodies orbiting the sun from west to east in their elliptical paths at approximately the same plane (the plane of the ecliptic) while rotating on their own axis. Kepler (1571 - 1630) discovered that the planetary orbits are elliptical rather than circular. The two major planets nearer the sun than the earth are usually referred to as the inner planets or the terrestrial planets. The other planets are the outer or celestial planets. At night the planets shine by reflecting the light from the sun. Venus, Jupiter, Mercury and Mars often shine more steadily and much more brighter than most stars. The inner planets and Pluto have no satellites (moons). While the earth has one, Jupiter has 12 out of the thirty-two moons in the solar system. See table 8.1 for some relevant statistics about the nine planets and figure 8.2 for relative sizes of the planets of the solar system.



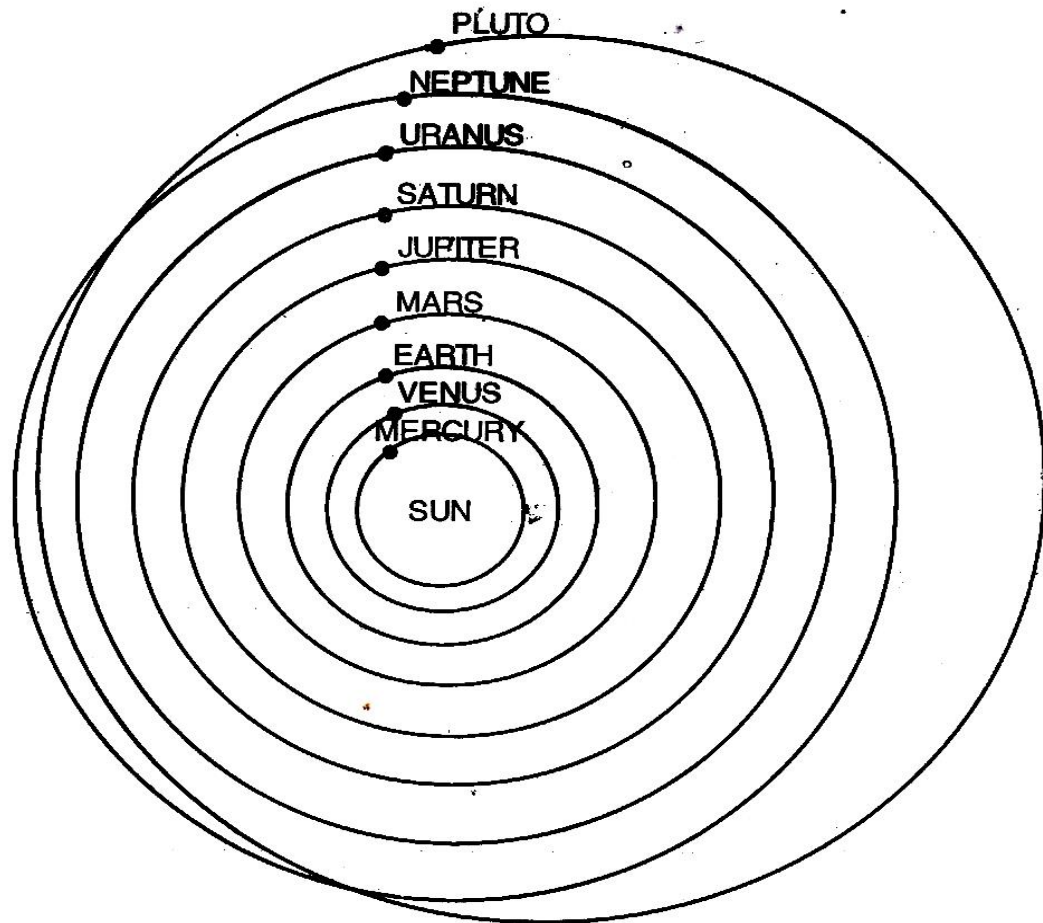


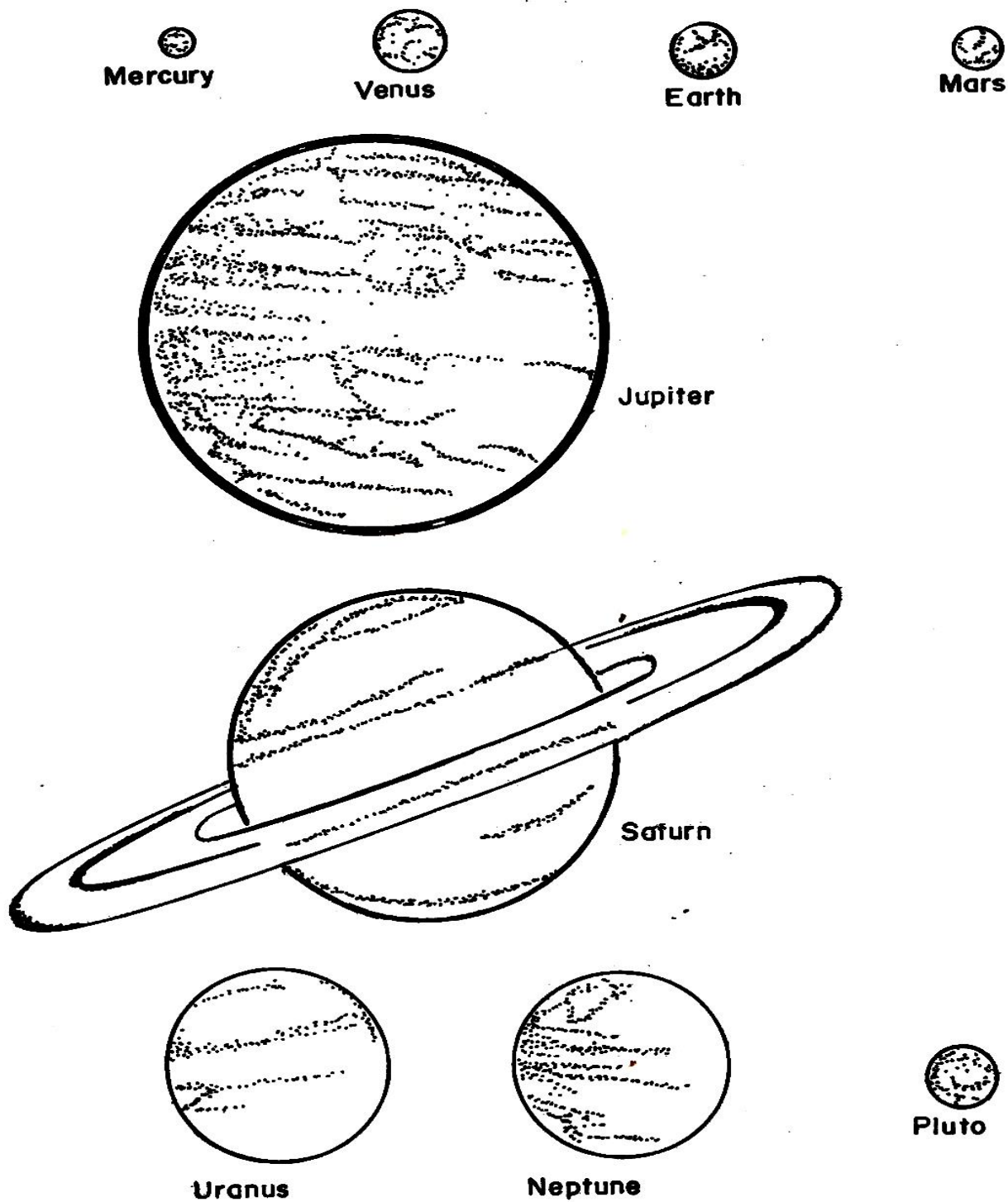
Figure 8.1 THE SOLAR SYSTEM

**Table 8.1: Some Statistics about the Nine Planets**

	Mean distance from Sun (millions of miles)	Equatorial diameter (miles)	Period (years)	Orbital inclination to plane of ecliptic	Density (water = 1)	Mass (Earth = 1)	Number of natural satellites
Mercury	35.98	3,010	0.24	7°0'	5.41	0.05	0
Venus	67.24	7,650	0.62	3°23'	4.99	0.82	0
Earth	92.96	7,926	1.00	0°	5.52	1.00	1
Mars	141.64	4,220	1.88	1°51'	3.96	0.11	2
Jupiter	483.64	88,760	11.86	1°18'	1.33	317.89	12
Saturn	886.70	74,160	29.46	2°29'	0.71	95.14	10
Uranus	1,783.1	29,300	84.01	0°46'	1.70	14.52	5
Neptune	2,794.1	27,800	164.79	1°46'	2.26	17.46	2
Pluto	3,666.2	3,700	248.4	17°10'	5.57	0.10	0

(Source: Man, Earth and Space. Caxton, 19. London: The Caxton Pub. Co. Ltd. 1966, p. 69)





**Figure 8.2 Relative Sizes of the Planets of the solar system**

**The Minor Planets** Apart from the nine major planets there are over 2,300 minor planets (planetoids or asteroids). They are located mostly between Mars and Jupiter.

**The Meteors** are relatively small bodies that travel through the space. When they come into the earth's atmosphere they can be seen as fireballs or shooting stars.



**The Comets** are small white bodies that orbit the sun on elliptical path. Each is made of a luminous nucleus and at least a tail. As it approaches the sun the nucleus heats up and releases some gas and dust which form the tail as the comet speeds on.

**The Satellites** are attendant's or moons attached to all planets except Mercury, Venus and Pluto.

## **The Earth**

This is the third planet from the sun. It is fifth in size. It is believed to be the only planet that sustains life. This is possible because of the general atmospheric balance which is life - sustaining.

**Table 8.2 : Some Statistics About the Earth**

1.	Age	About 4.6 billion years
2.	Shape	Geoid or oblate spheroid
3.	Position from the sun	3rd
4.	Mean distance from sun	149,500,000 km (93 million miles.)
5.	Distance from sun (June 21)	151,120,000 km (94,450,000 miles)
6.	Distance from sun (Dec. 22)	146,128,000 km (91,330,000 miles)
7.	Relative Size	5th Largest
8.	Land Mass	30% (150 million $km^2$ ; 7,500,000 sq miles)
9.	Water Mass	70% (361 million $km^2$ ; 139.4 million sq miles)
10.	Total Surface Area	511 million $km^2$ (197 million sq. miles)
11.	Equatorial Diameter	12756 km (24,900 miles )
12.	Mean Radius	6330km (3956 miles )
13.	Circumference	40,070 km (24,900 miles )
14.	Polar Diameter	12637 km (7898 miles )
15.	Atmospheric, Thickness	About 200 km (125 miles)
16.	Average speed around the Sun (revolution)	30km (18.5 miles) per sec.
17.	Average speed on its axis (rotation)	23 hours 56 minutes, 4.1 seconds
18.	Year = complete orbit (sidereal period)	365 days 5 hrs 48 mins. 46 seconds
19.	Satellite	one moon
20.	Beginning of life	About 4 billion years ago

Prior to Galileo's discovery of astronomical telescope in the 17th century the earth was thought to be the centre of the universe. By the early 20th century the concept was modified. The solar system was then thought to be the centre of the universe. After the Second World War and following new developments in radio telescope and optics technology, this geocentric concept was revised. The great revelation is that the solar system in which the earth is a member is in one remote part of our spiral galaxy (the Milky Way) which is just one



of the millions of other galaxies that dot the vast boundless and expanding universe.

## **Origin of the Earth**

Various theories and explanations exist. These can be grouped into three: local mythologies, Theological views and the Scientific theories.

### **(a) The Local Myths**

Every culture, whether sophisticated or primitive, has myths. These worldwide ancient traditional stories of gods, supernatural heroes and the past usually offer explanations of some unknown situations and cultural origin. However, myths of a particular people usually show some similarities with those of other cultures. But all cultures associate myths with the gods, supernatural powers, religion and local cultural origin. Because myths explain something important about the cosmic phenomena, geographical features, names, events in the remote past, heroes and the gods or sociocultural phenomena which cannot be easily explained nor comprehended by the human mind, the tendency is to accept them as truths. Myths also provide the basis for explaining how, out of original chaotic situations, order originated to regulate and direct future events.

Local myths cannot be completely dismissed as being scientifically baseless. Some Egyptian, Roman and Greek mythologies, for example have provided dependable basis for some scientific explanations of modern times. Some technological and scientific names and expressions including names of planets such as the Venus, Mars, Jupiter, Pluto and some of months of the year such as January and June have mythological origin. In Nigeria, the mythologies of the Ibibios, Ibos, Yorubas and Hausas, among others, often point to both their mystical origin and that of the earth. Such myths are usually associated with the sky, fire, sun, water, totemic animals and heroes. In each case a superior being or force, seen as the primary force of the cosmological era, was present. From this superior being stemmed the origin of the universe and all the elements, giving life to all creatures and creation.

You will realize that although it is difficult to find any empirical or logical evidence in support of these myths of origin, they have nevertheless been accepted as having contributed significantly to the scientific and technological evolutionary thoughts.

### **(b) The Theological View-points**

Various religions accept that the earth was created by God or the Supreme Being (whatever name the creator is given). The Christian religion, for example, in Genesis chapter one, among others, emphasizes the theory of creation and command. An instance is that the heaven and earth, land, animals and man were created (see Genesis 1 : 1, 21, 26) whereas light, plants and water came into existence by command (see Genesis 1 : 3, 14, 24). Other great religions of the earth seem to accept this theological view.

**Proofs:** No scientific theory has been able to prove why nor how the initial gas or dust started. Most scientists believe there is a prime mover or ultimate force behind all creation which the human mind cannot clearly perceive.



### **(c) The Scientific View-points**

These vary with physicists, astronomers and philosophers interested in cosmology. Scientific viewpoints have also been continuously revised when new evidence are made available. Among the numerous related ones, the meteorite hypothesis and the nebular hypothesis (both of which help to explain the gradualistic theory) and the big bang theory will be briefly discussed.

#### **The Meteorite Hypothesis:**

Meteorites are fragments of solid spatial matter that arrive the earth from the space. Their sizes could vary from particulate matter to large fireballs weighing thousands of tonnes. Their exact origin in the space is not certain. Some scientists believe they come from other planets while others believe they originate from asteroids which are thought to be the fragments left over after the formation of the solar system.

Meteorite hypothesis proposed that the solar system originated from the collision of some freely moving spatial solid matter. This phenomenon flung out the varying sizes of the particles of the colliding meteorite into space at varying speeds to form the planets, leaving the asteroids as minute residue of the collision. The planetary positions are so maintained because of the initial force of gravity and the magnetic force of the sun.

However this hypothesis has not provided convincing evidence for the origin of the sun nor what gave rise to the meteorites and the expanding universe as it is currently observed.

#### **The Nebular Hypothesis**

Nebulae refer to clouds of gas and dust in the space. They are the "birthplaces" of the stars. Among some writers associated with the nebular hypothesis are de Laplace, P. S. (1749-1827), Immanuel Kant (1724 - 1804), Karl Friedrich Von Weiszacker (1912-?) and G. P. Kuiper. They are the gradualistic theorists.

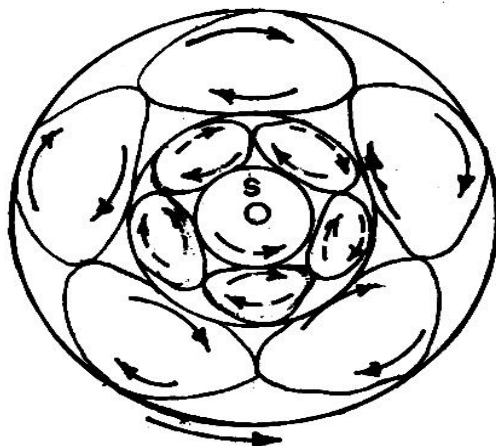
One version of the nebular hypothesis proposed by Weiszacker is referred to as the "Dust-cloud" hypothesis. K. F. Von Weiszacker was a German professor of Physics and an astronomer interested in evolution of galaxies and the solar system. In 1938 he proposed the carbon circle of nuclear changes which accounted for the sun's radiation. In 1944 he offered a new nebular hypothesis of the origin of the solar system involving turbulence in a dust-cloud. Essentially Weiszacker hypothesized that there was once an aggregation of particulate matter forming the cloud (nebulae). When it came in contact with the sun, concentric rings of particles were formed with the sun at the centre with five vast eddies each (see fig. 8.3). The dust which collected in between the eddies formed the planets which were initially intensely hot but which later became molten.

G. P. Kuiper worked on this hypothesis which has remained one of the most plausible hypothesis explaining the origin of the solar system. The new (dust-cloud) nebular hypothesis superseded the earlier nebular hypothesis of John Jeans and H. Jeffreys otherwise referred to as the "tidal theory" of 1901. The "tidal theory" proposed that a passing star pulled a huge cigar-shaped bundle of matter out of the sun. When the matter condensed, planets were formed (See figure 8.4).

Kant (1724 - 1804) and Laplace (1749 - 1827) among other gradualistic theorists believed essentially that the solar system in which the earth is a member,



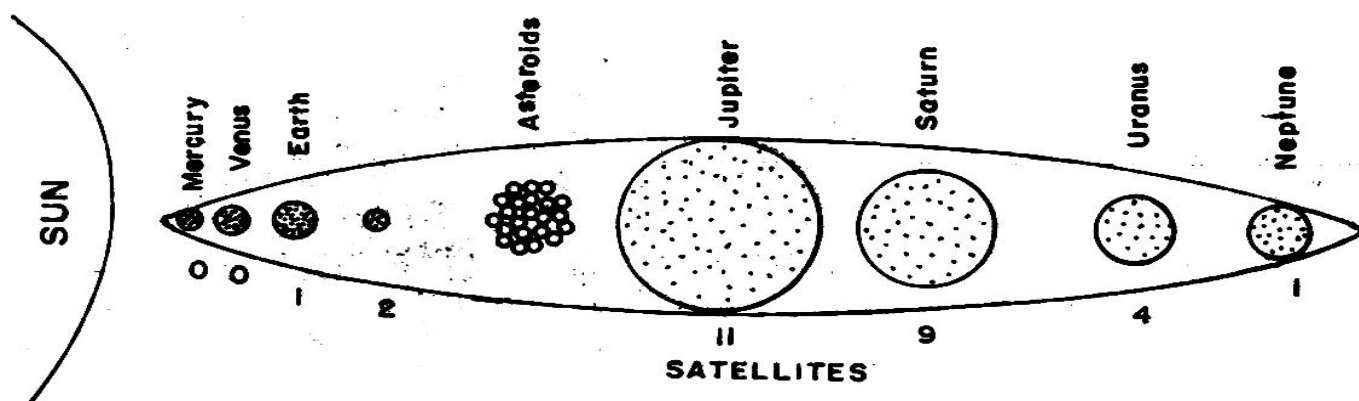
was formed gradually following the cooling process of the molten materials flung out by the hot rotating gas (sun). They also believe in continuous creation saying that although stars and galaxies are "aging" and "dying" the energy they emit still remain as new materials, from which new stars and galaxies form.



**Figure 8.3 The Nebular(Dust-Cloud) Hypothesis.**

"Captured concentric rings circling about the sun fall into concentric rings of five vast eddies each."

Source: New Caxton Encyclopedia(1968:4774),



**Figure 8.4 Tidal Theory**

Source: New Caxton Encyclopedia(1968:4774)

The theory asserts that the solar system was derived from a rotating molten nebula whereby the molten matter progressively got detached from the mass of rotating hot gas to form the planets. The process of cooling caused the planets to contract, increase their velocity and shape up. The sun itself, according to this theory, is a residual nucleus of the original nebula, condensed and heated up by gravitational contraction. They accepted that the detached material kept orbiting the hot gas (sun) in their elliptical paths because of initial magnetic and gravitational forces earlier generated and maintained by the sun.

Explanatory points associated with the gradualistic theory are that:

- (a) The internal structure of the earth is still hot probably as a result of the inherited heat at its formation.
- (b) Rocks in all parts of the earth suggest molten origin.

- (c) The envelop of gases surrounding The planets are believed to have been inherited from the initial mass of hot molten matter.
- (d) The age of rocks which is between 3 - 5 billion years suggest that they are slightly younger than the sun from which they originated.
- (e) Irregular cooling of the molten matter resulted in geographical shrinking of the earth that has led to the formation of valleys and mountains.

## The Big-Bang Hypothesis

The big bang theorists believe that the universe was initially made up of one hot super-dense matter. Between 20 and 10 billion years ago there was an original sudden explosion probably arising from the intense concentration of matter in a very restricted space.

They propose that the explosion threw out different sizes of particles of molten materials at different speed. These later condensed to form the planets. As the hot materials were flung out at different rates by the sudden loud explosion, the universe kept expanding from its original restricted space (see Meteorite hypothesis).

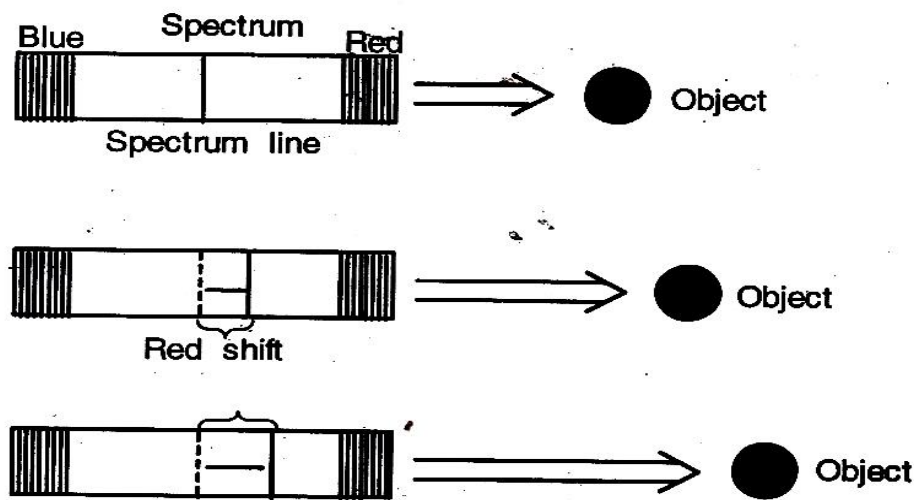


Figure 8.5 The Red Shift

Source: Century Hutchinson (1979)

Explanations associated with the big bang theories are that:

- (a) Cosmological findings which focus on the structure of the universe support the idea of the expanding universe.
- (b) Actual observations in plate tectonics show that the continents are still drifting and that the sea-floor is spreading (continental drift and sea-floor spreading) giving rise to volcanoes and the creation of new materials at the sub-duction zones. (Compare Alfred Wegener's hypothesis in fig. 8.6)



- (c) The red shift used mostly in astronomy confirms the continuously expanding universe (a continuing effect of the Big Bang) as observed in the lengthening of the wavelength of light from the object as a result of its motion away from the observer (see figure 8.5).

Whatever may be the origin of the Solar System and the planets, geologists have, among others, the following theories about the earth.

## 1. The Continental Drift

The continental drift is a theory that the earth's land masses slowly changed their relative positions by drifting away from the core. It was first suggested by Snider in 1858, that the two coast-lines of the Atlantic can fit together like pieces in a jigsaw and that such arrangement was too natural to be a coincidence.

Alfred Wegener (1880 - 1930) between 1910 and 1915 proved Snider's proposition with amazing body of evidence to show that the land masses of America, Antartica, Australia and India were all in actual contact with the Africa land mass (see figures 8.6 a, b, and c). He suggested that all the masses (continents) in the world were, during the paleozoic age, a single mass which he called "PANGAEA". Edward Suess, an Austrian geologist, called the Southern part the "GONDWANALAND". The progressive separation of the land - masses which consist of *sial* (*silica* and *alumina*) or the *continental crust floating on the sima* (*silica* and *magnesia*) or the ocean crust produced the earth crust. Owing to some forces the movement or drift is still continuous so the shape and positions of the land masses are still relative, not absolute. Evidence from rock samples, fossils, flora and fauna at the same latitude from the different continents strongly suggest that they have similar origin. Wegener's theory of continental drift proposed in 1915 has today been further substantiated by concepts of plate tectonics and sea-floor spreading. These concepts emphasize that there is an on-going continual formation and destruction of the sea-floor layer of the earth. The sea-floor is made up of major and minor plates fitted together like the jigsaw (see fig. 8.7). The convection currents within the mantle continually upwell bringing with them some new molten materials. Along the plate joints the spreading sea-floor plates over-ride one on the other, away from the ocean ridges. The juxtaposed materials result in subduction zones at the ocean trenches. As the subducted materials are absorbed back into the mantle and new ones come out, the sea-floor gradually expands pushing the continents apart. Major active volcanoes and earthquake belts are also associated with the subduction zones; major fold mountains also occur in very close association with them (see figure 8.8)

## 2. Isostasy

The concept of isostasy or isotatic equilibrium states that every land mass, mountains for example, have roots which stabilize them. The isostatic theory was first proposed by George Airy in 1855 and later elaborated upon by Dutton in 1889 and by Wegener in 1912. It relates to the theoretical balance in bouyancy of the earth crust. Isostasy expresses that the light crust (*sial*) floats on the dense one (*sima*). In mountainous areas for example, the *sial* layer which floats on the *sima* substratum is immersed at much greater depth in the *sima* than in the plains and low land areas where the *sial* layer has not penetrated the *sima* substratum. This situation results in the isostatic equilibrium similar to hydrostatic equilibrium and principles of floatation. Isostatic equilibrium does not however operate at constant rate everywhere owing to the process



of erosion and deposition, differential densities in the earth crust, orogenic movements and magnetic phenomena.

What all these theories have however not pointed out is the nature and content of the original hot gas or hot dense material, what caused its motion and the eventual exploitation. These may reinforce the concept of the ultimate source, the Prime Mover, Super Intelligence or God which the theological view-points emphasize.

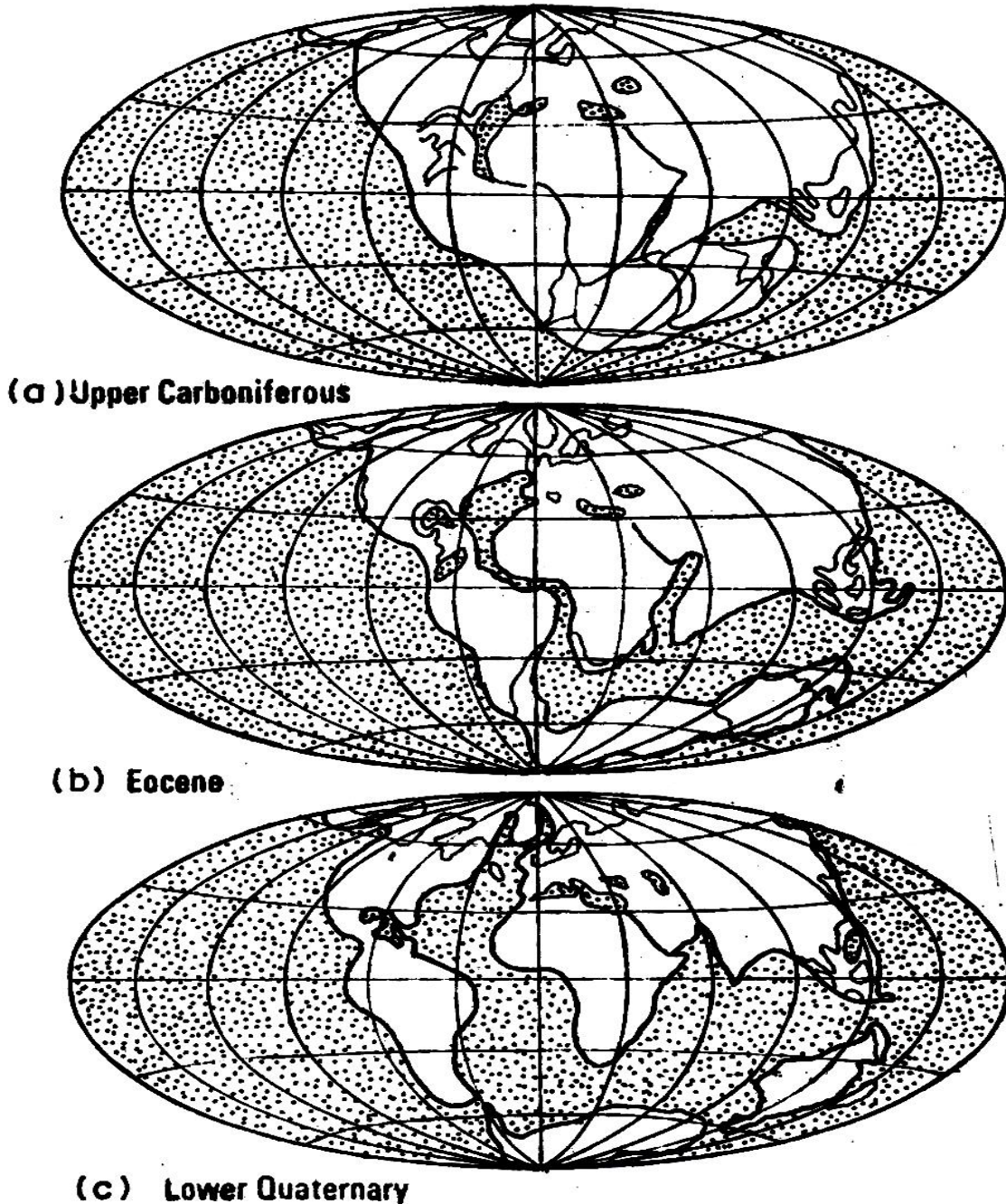
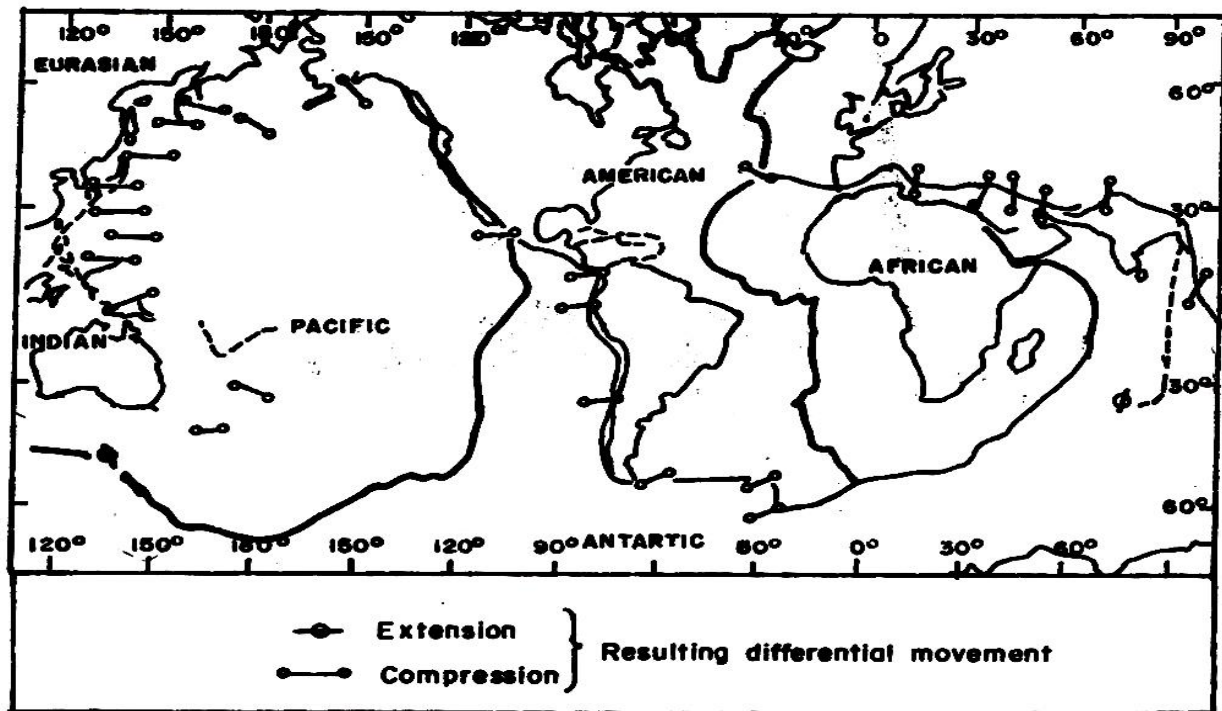
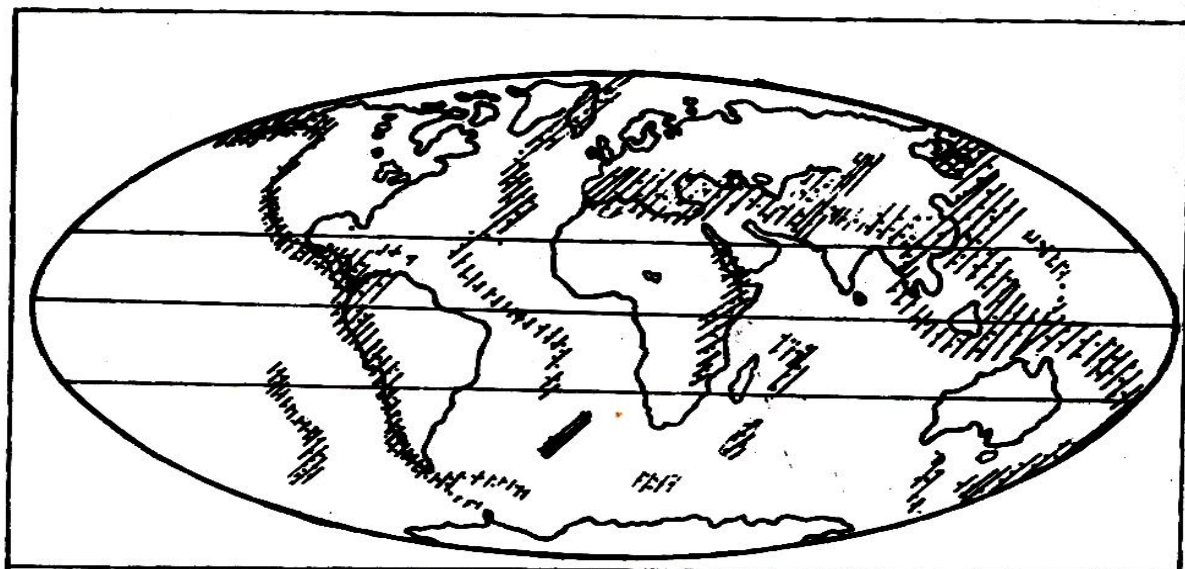


Figure 8.6 Wegener's hypothesis





**Figure 8.7 The Six major Tectonic Plates**

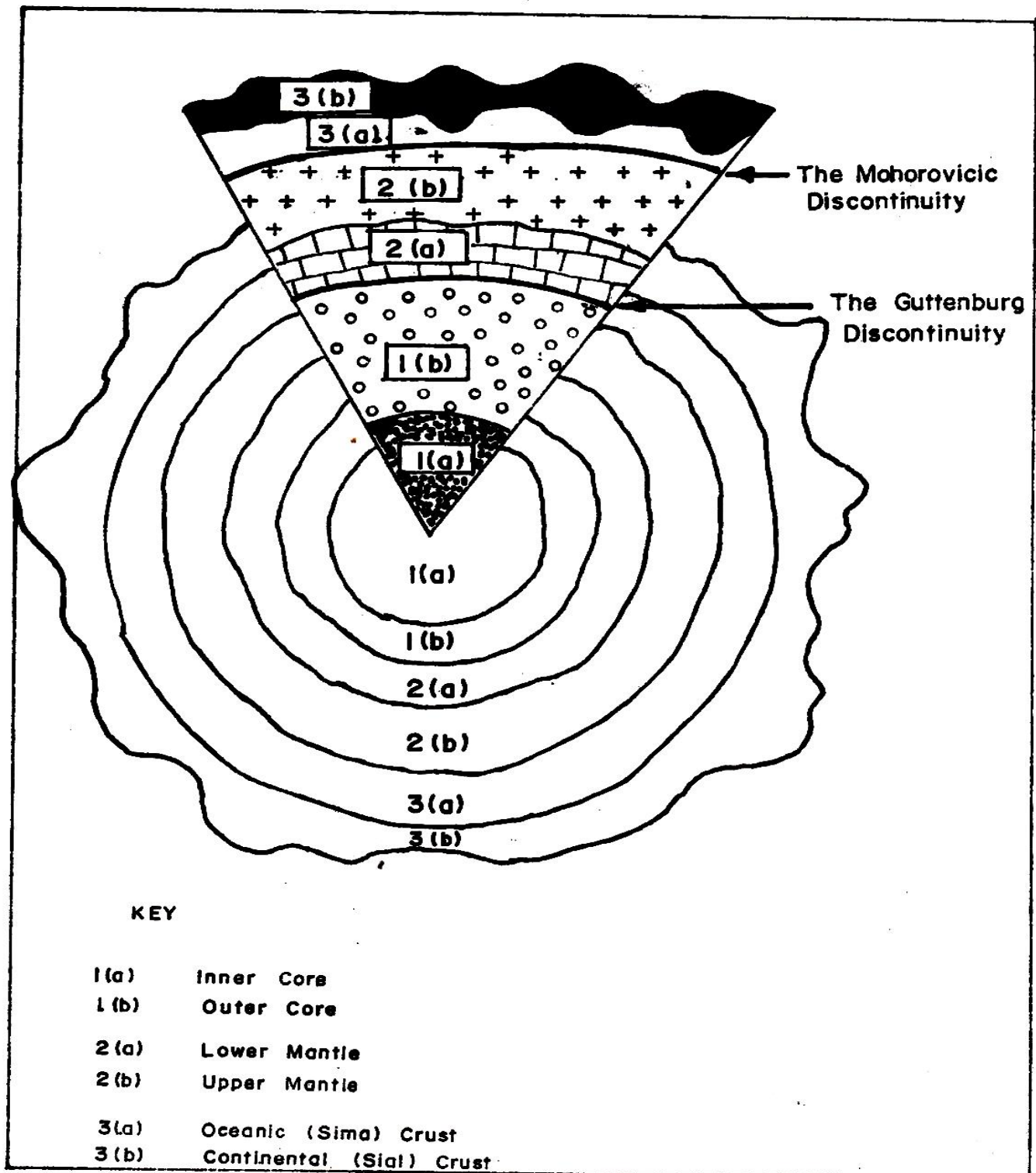


**Figure 8.8 Global Earthquake Belts**

### **The Internal Structure of the Earth (Geological Zones)**

The constitution of the earth has been observed and studied through evidences made available by volcanoes, plutonic rocks brought to the surface by past tec-

tonic movements and boreholes. All available evidence show that the internal structure of the earth can be seen as concentric circles (see figure 8.9) with the lightest at topmost and the thickest at the innermost. This idea was first proposed by Suess' (1885), three concentric lithospheric layers with differing densities. These layers are the crust, mantle and core.



**Figure 8.9 Internal Structure of the Earth**

### The Core

The core occupies the central portion of the earth. It is made up of the inner and the outer layers. The inner core is about 2600 km (1600 miles) in diameter



while the outer core is about 2250 km (1400 miles) thick. Both inner and outer cores are accepted to be made up of *nife* (*nickel*) and iron (*ferrum*). The inner core is solid while the outer is molten and contains currents responsible for the earth's magnetism. The temperature at the core may average about 3,000°C. The marked junction between the outer core and the next layer is called the Guttenburg discontinuity, after its American discoverer, B. Guttenburg.

## The Mantle

This is the middle layer of the earth's internal structure. It lies above the molten core and the crust. It consists of silicate rocks such as olivine at the upper mantle and spinel at the lower. The mantle constitutes the rigid plate of the earth's structure. It is about 2,900 km (1800 miles) thick. The mantle is subject to convection currents in which the rock flows in solid state giving rise to the subduction zones and allowing, at its weak points, the molten core matter to be forcefully ejected as volcanoes.

## The Crust

This is the outermost and thinnest of the concentric layers of the earth's internal structure. It consists mostly of silica, with alumina at the continental or uppermost crust and with magnesia at the oceanic crust below. The oceanic crust is about 10 km (6.2 miles) thick and fairly even in composition. It exhibits much younger age characteristics than the continental crust. They are accepted to be about 200 million years old, - probably owing to the continuous movement of plate tectonics. The continental crust exhibits great variety, is more complex and some may be over 2 billion years old. Granite and basalt typify the continental sial and oceanic sima respectively. The crust and the upper layer of the mantle together form the twelve major plates upon which the continents drift. The sharp contrast between the crust and the mantle that marks their junction is the "Moho" or "Mohorovicic discontinuity" (named after a famous Yugoslav Seismologist, Andrija Mohorovicic). This discontinuity occurs about six to seven miles below the sea-level.

## Earth Movements

The earth has several complex motions, most obvious of which are the following:

### (a) Rotation

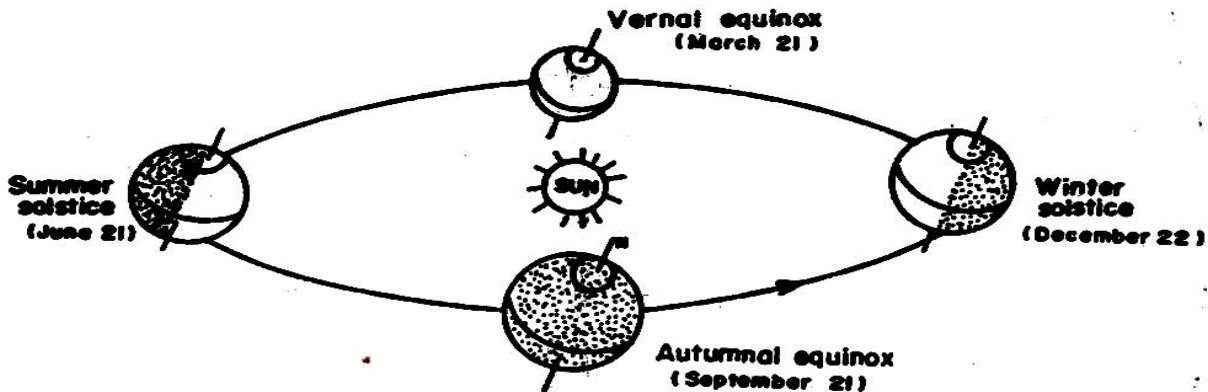
The earth rotates on its axis from West to East once in 23 hours 56 minutes 4.1 seconds (about 24 hours). This motion produces an illusion that the sun and other heavenly bodies move across the sky from East to West. The side of the earth, as it rotates, that faces the sun has light or day but the opposite side has darkness or night. The actual duration of daylight or darkness varies from 24 hours of complete darkness to 24 hours of complete daylight at the poles, the equator always having 12 hours of each.

### (b) Revolution

As the earth rotates on its axis it also revolves in its elliptical orbit around the sun. It takes the earth 365 days 5 hours 45 minutes 46 seconds (one year) to complete one revolution. The plane of earth's revolution is called the "plane of the ecliptic". The orbit is about 934.4 million km (584 million miles) long so that the earth takes the speed of 30 km (18.5 miles) per second to revolve once completely around the sun.



The earth's axis of rotation has an inclination of  $66.5^\circ$  to the plane of the ecliptic. The constancy of the inclination results in seasons of the year and differential duration of daylight at different latitudes. This is because as the earth moves from one part of the elliptical orbit to the other, the north or the south pole alternately points to the sun. Moreover the elliptical nature of the orbit makes it that the earth will be either nearest to or furthest from the sun twice during any single revolution (see figure 8.10).



**Figure 8.10 Orbital Positions of the Earth in relation to the Sun and the Seasons.**

This relative position of the earth to the sun also results in solstices (when the earth's celestial equator is furthest from the sun around June 21 and December 22) and in equinoxes (when the earth's equator is directly under the sun on March 21 and September 21) thus resulting in equal duration (12 hours each) of day and night on all parts of the earth). The summer solstice (June 21) means people around the north pole have 24 hours of daylight while the winter solstice (December 22) results in the reverse. For those around the south pole the reverse is true: December 22 is their summer solstice while June 21 is their winter solstice. There is usually a slight change in date because the year is not exactly 365 days.

**(c) Other Movements include the following:**

**(i). The Irregular Perturbations** which are caused by gravitational influence of the other planets in the solar system.

**(ii). The Periodic Movements:** Precession and nutation are two examples.

Precession of the equinoxes is slow wobbling of the earth on its axis. The wobbling or precession which occurs essentially at the earth's axis is caused by a combined effect of the gravitational pull of the sun and the moon on the equatorial bulge. It causes the earth's axis to trace out a circle on the sky every 25,800 years.

Nutation is a regular slight "nodding of the earth in space. This results from differential gravitational pull of the sun and the moon. Some slight changes in the angle of earth's axial tilt from  $23.5^\circ$  is caused by nutation. It takes about 18.5 years for a complete side to side "nodding" to take place. The earth is also undergoing progressive slowing down of rotation because of tidal friction generated by the lunar gravitational force.

Finally the earth along with other members of the solar system continuously revolve around the galactic centre. It takes about 200 million years for the solar



system to complete one galactic rotation (cosmic year) at the rate of about 272 km (170 miles) per second.

## **Crustal Mobility and Earth Sculpturing Processes**

The sculpturing of the surface of the earth results from combined effects of both internal and external processes of crustal mobility. Most often these processes occur in relatively quick succession, at other times very slowly and imperceptibly. The most obvious internal dynamics of the earth crust are volcanoes and seismic disturbances, others not very obvious are folding and faulting. Volcanic actions indicate internal chemical and thermal activities; seismic disturbances, folding and faulting are evidence of physical and mechanical actions. All orogenic processes result in surface features that change the shape of the landscape. The external crustal mobility processes include weathering, erosion, deposition, glaciation, among others.

### **Internal Orogenic Processes**

Orogeny is mountain building by dislocation. Such internal processes are explained by theories of isostatic equilibrium, continental drift, plate tectonics and gravity tectonics. Our focus will now sharpen on gravity tectonics, magmatic current theory, folding and faulting.

#### **Gravity Tectonics**

Gravity is the force of attraction between two objects because of their masses. Based on this concept gravity tectonics explains the deformation of the earth crust as a result of gravitational pull. It accepts that the force of gravity causes the strata (sial) on inclined surface of the earth to break apart, slide down the underlying (sima) slope and form folds. Because the underlying materials are not affected by the movement they become exposed to weathering processes.

### **Magmatic-Current Theories of Orogenesis**

Magma is subterranean molten material made up of solids and gases which when solidified forms igneous rocks. When released by volcanoes they are referred to as lava. Their movement result in formation of volcanic mountains and associated features.

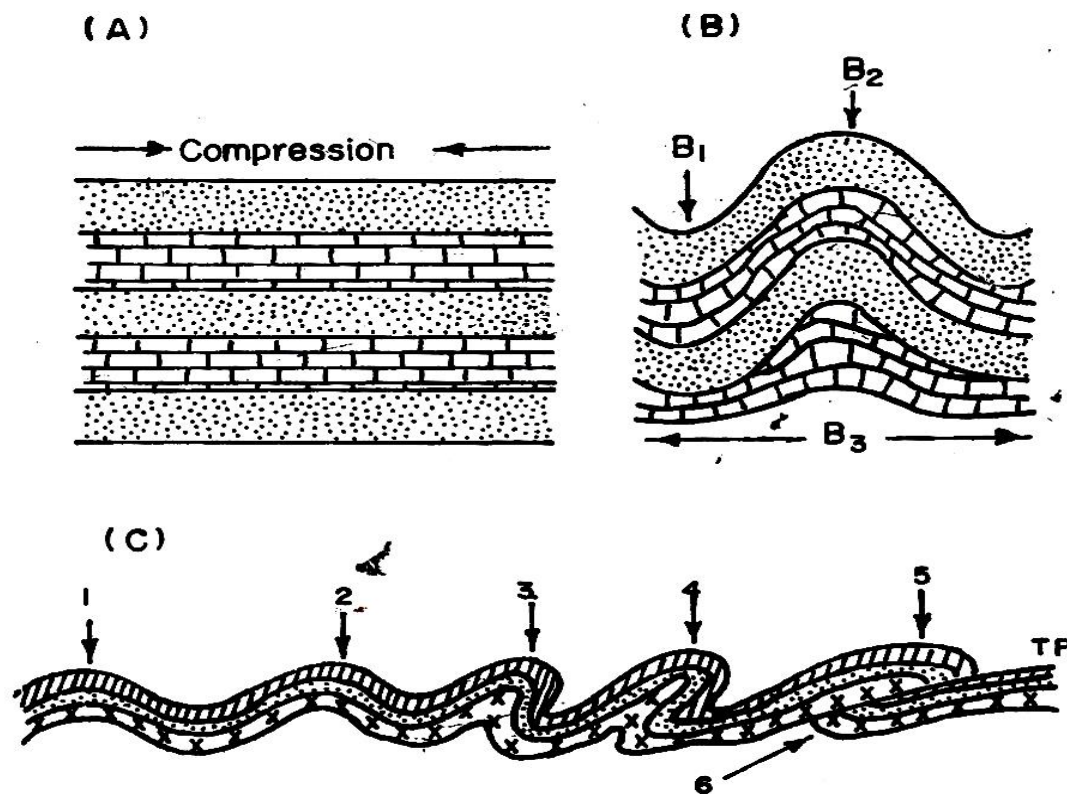
#### **Folding**

Folding is a bend in rock beds which form synclines (downward sag in the middle of rock bed) and anticlines (arching up in the middle of rock bed). It occurs mostly in sedimentary rocks. It results from lateral compressional forces affecting the earth crust. Folds can be simple, asymmetrical, overfold, recumbent or overthrust (see figure 8.11) depending upon the intensity of the compressional forces and the varying degree of push. They result in fold mountains such as the Alpine-Himalayan range and the Circum-Pacific System.

#### **Faulting**

A fault refers to a sudden fracturing displacement or dislocation of the sial because of tensional and/or compressional force in the crust (see figure 8.12). Displacement of sial masses horizontally or vertically, if microscopic, may not have immediate noticeable effects, but massive sial dislocations can cause major earthquakes. Faults may occur anywhere including areas that had already undergone folding. They result in block mountains such as Mount Sinai, Vosges

and Black Forest and Rift Valleys such as those in East Africa running from Middle East to Lake Malawi in East Africa.



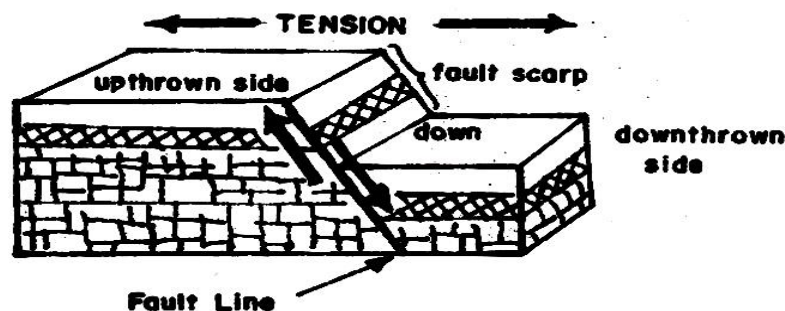
**Figure 8.11 Nature and Types of Folding**

**A: Before Folding B: After Folding C: Types of Folds**

**Key**

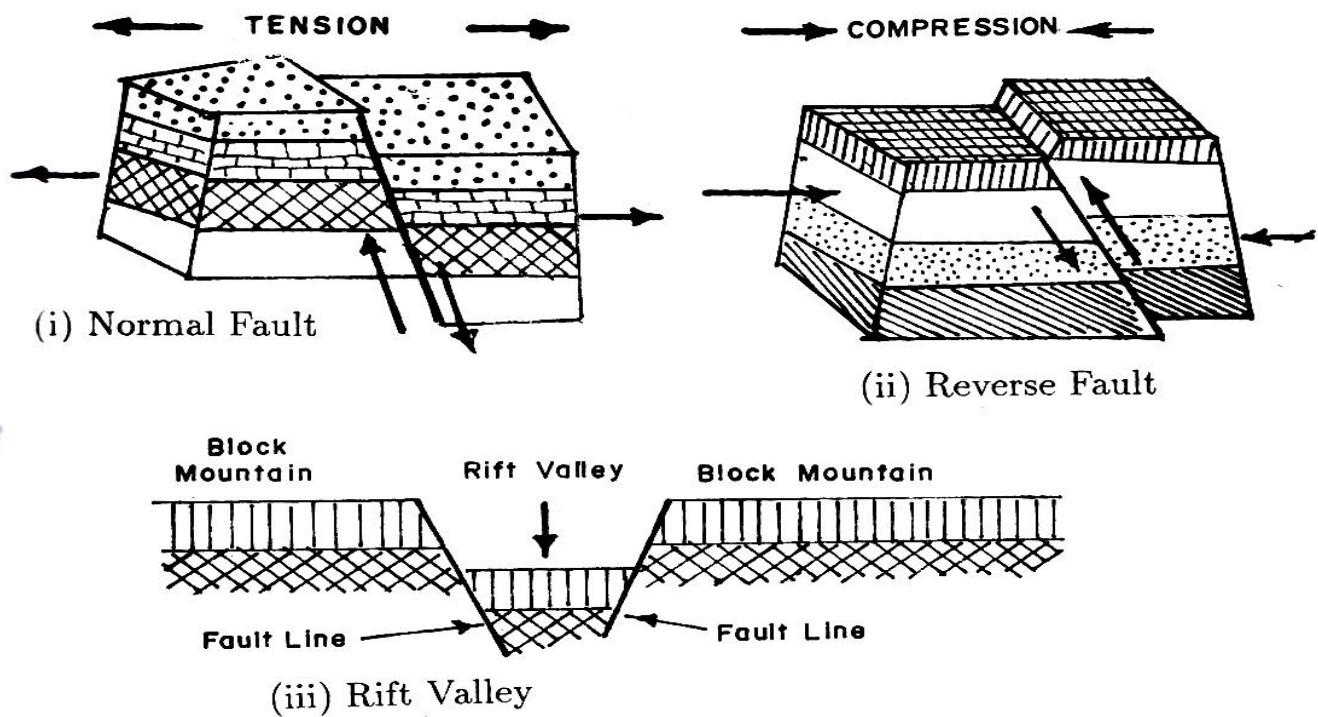
- $B_1$  : Syncline
- $B_2$  : Anticline
- $B_3$  : Shortened crust
- $C_1$  : Simple fold
- 2 : Asymmetrical fold
- 3 : Overfold
- 4 : Recumbent fold
- 5 : Nappe
- 6 : (TP) Thrust plane

**A: Nature of Fault**





### B: Types of Fault and associated Valley



**Figure 8.12 Nature and Types of Faults**

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