Unit–2

THE EARTH AND THE UNIVERSE

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Introduction

The Earth and the Universe is the second unit of The General Science Course. It is observed that teachers and students are not clear about the concepts of Earth and the Universe Sciences. It is important to discuss the concepts related to the Earth and the Universe. So the aim of this unit is to present the basic knowledge about Astronomical bodies, the Solar system ,theories of origin of Earth, the lithosphere, the hydrosphere, the Galaxies, the Black holes and about the Space. The writer intends to create motivation and curiosity and the students may be able to gain the knowledge about the Universe. Major purpose of this course is to enhance knowledge competence of prospective teachers to enable them to teach science effectively. The content of this unit is comprised of basic concepts of earth sciences and astronomy. This unit also helps the teacher to gain the skills for meaningful teaching.

For many centuries, our forefathers thought that "Our Earth is the center of the Universe". Now, science has enabled us to know that it is not so. The Earth is located in the Orion Super off the Perseus arm in the Milky Way Galaxy. Where the Milky Way falls in the scope of the entire Universe is still to be determined .In fact Astronomy and Geography has become very vast and comprehensive disciplines prehistorically. All concepts are interlinked and they provide a self explanatory text. The aim of this chapter is to create a love and curiosity for Geography and Astronomy among the students of ADE.

Objectives

After studying this unit, the reader will be able to.

- describe basic concepts regarding astronomical bodies.
- illustrate solar system.
- explain the theories of origin of earth.
- discuss motion of the earth.
- appraise the importance of lithosphere and Hydrosphere.
- differentiate and compare Oxygen, Ozone, and Ozone layer.
- distinguish galaxies, black holes and the space.

2.1 Astronomical Bodies: An introduction

Astronomical bodies are naturally occurring physical structures or associations that can be found in the Universe.

If we count all the stars, there are trillions of trillions stars and our Sun is one of them. Astronomers are those people who study astronomical bodies. Our Universe is continuously expanding, and exact location of the Sun is not exactly known. Astronomers are also not able to see everything in the universe.

If we take example of our solar system, then the Sun and all those bodies (entities) which revolve around the Sun are called astronomical bodies. They include the sun, stars, planets, moons, asteroids, comets, meteoroids and meteors.

2.1.1 Stars

A star is an astronomical body which emits light produced in its interior by nuclear 'burning'. Stars are hot bodies of glowing gas. e. g The SUN.

2.1.2 Planets

Planets are astronomical bodies which do not have their own light, they are cold bodies. Planets revolve around the sun and shine by reflecting light. Earth is an example of a planet.

2.1.3 Moon

Moon is also called a natural satellite, which revolve around the planets. The planets have different number of moons; for example, Mercury and Venus have none, the Earth has one moon, and Jupiter has seventeen or more, Saturn has nine, Uranus has five, Mars and Neptune each have two moons. The moons also shine by reflected light.

2.1.4 Asteroid

Asteroids are heavenly bodies that orbit the Sun between mars and Jupiter. They are composed of carbon, metals, or rocks.

2.1.5 Comet

Beside planets and Asteroids some other objects also orbit the sun. They are called Comets. A Comet is a heavenly body made up of ice and dust particles. They are only seen when they come near to the Sun. During orbiting near the sun, a long tail of gases and dust particles is formed behind the comet. Far from the Sun it is difficult to distinguish between asteroid and a Comet. A Comet is a heavenly body, looking like a star with a bright head and a less bright tail.

2.1.6 Meteoroid

There are other bodies smaller than Asteroids called Meteoroids. A meteoroid may be the size of a grain to the size of a boulder. (Boulder is a large piece of rock or stone, especially one that has been rounded by water). When a meteoroid enters the atmosphere

of our earth, it is called a meteor. Its size may be equal to the size of a grain of sand. Meteors are small bodies rushing from outer space into the Earth's atmosphere and becoming bright as a shooting star or falling star as it bursts. Something the size of a football would be extremely bright, and could potentially hit the ground. Extremely bright Meteors, or meteors that explode are known as **bolides**.

2.1.7 Meteor

A trail of light seen when a meteoroid is burnt by friction with the earth's atmosphere. They are also called *falling star*, *meteor burst*, or *shooting star*.

Key Points

1. All the physical structures which can be seen in the universe are called Astronomical bodies.
2. Stars, planets, moons, asteroids, comets, meteoroid and meteor are astronomical bodies.
3. Star is an astronomical body which has its own light.
4. Planets are those astronomical bodies which do not have their own light. Planets revolve round the stars/sun.
5. Moons are also called natural satellites, which revolve around the planets. They also shine with the reflected light.
6. Asteroids are astronomical bodies that revolve around the sun between Mars and Jupiter.
7. A comet is an astronomical body which form a long trial of dust and gases when it is orbiting the Sun.

Self Assessment Exercise 2.1

Q.1 Fill in the blanks with suitable words.

i. The Sun has its own_____ ,so the sun is called a Star.
ii. When a _____ enters the earth's atmosphere it is called a meteor.
iii. Asteroids are heavenly bodies that orbit the Sun between _____ and Jupiter.

Q.2 Answer the following questions

i. Write names of all astronomical bodies, and write a detailed note on any three of them?
ii. Define the followings. Astronomical bodies, Stars and Planets.

Q.3 Choose the correct answers.

i. The are nine in number and shine by reflecting light.
   a. moons b. stars
   c. planets d. comets

ii. A piece of rock or stone, rounded by water is called.
   a. satellite b. bolides
   c. boulder d. comet

iii. Moons revolve around the planets, the number of moons that revolve around the Mars is.
   a. 2 b. 3
   c. 1 d. 8

2.2 The Solar System and Heavenly Bodies

The Solar system consists of the Sun, the nine Planets which orbit round the Sun and some smaller bodies like moons and comets.

The orbits of all except two planets, lie in nearly the same plane, so that we can say, the solar system is disc shaped. All planets revolve counter clock-wise round the Sun. The Solar system consists of these nine Planets

1. Pluto	**2. Neptune**	**3. Uranus**
4. Saturn	**5. Jupiter**	**6. Mars**
7. Earth	**8. Venus**	**9. Mercury**

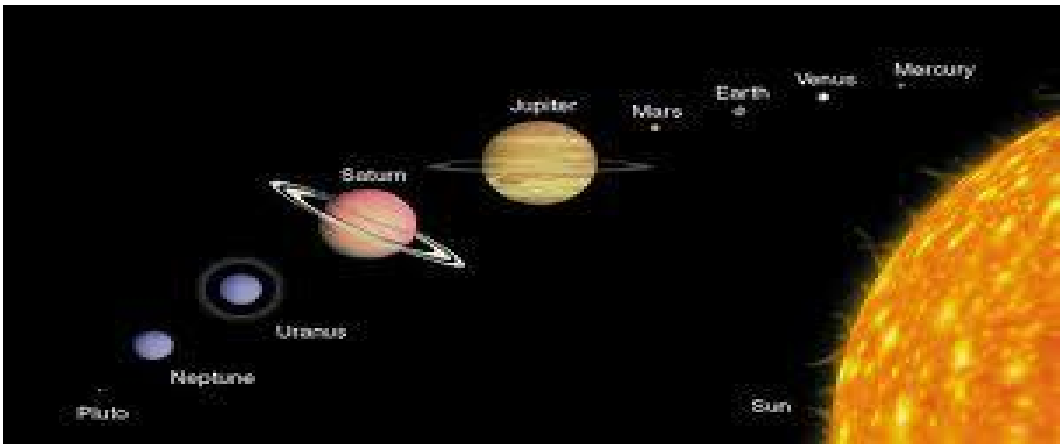

Fig.1 Our Solar System

1. Pluto

An interesting argument about Pluto is that some Astronoers hesitate to consider Pluto as a planet. Although it was discovered in 1930 by a famous Astronomist Claytomiag. Researches have shown that Pluto was a moon of Neptune. It escaped from the orbit of Neptune and adopted another orbit and became a planet. It is 5,900 million kilometers away from the sun. Its diameter is 3,00 kilometers. It completes its rotation around its axis in 6.4 days, and revolution around the Sun in 248 years. Its speed is 5 kilometers per Second.

2. Neptune

A French Scientist Leoprace and a British Mathematician Adems discovered this planet in 1846. Neptune is slightly smaller than Uranus. It is more massive and dense. It radiates internal energy. But this energy is less than Jupiter and Saturn. Neptune has 13 satellites. The largest, Triton, is geologically active, with geysers of liquids nitrogen. There are many smaller planets in its orbit called Neptune Trojans. It is 4,497 million kilometers away from the Sun. Its diameter is 48,600

Fig. 2 Neptune

kilometers. It rotates around its axis in 15 hours, and completes its revolution around the Sun in 165 years. Its speed is 5 kilometer per second.

3. Uranus

Fig.3 Uranus

Uranus was discovered by famous Astronomist William Hershell in 1781. He called it George but later on Scientists changed this name into Uranus. Its average temperature is -217^{o}C. Its core is much colder and radiates much less heat into space, as compared to other gas giants. Uranus has twenty seven satellites, the largest ones being, Titania, Oberon, Umbriel, Ariel and Miranda. The distance of the Uranus from the Sun is 2,870 million km .Its diameter is 50,800 km. It completes its rotation around its axis in 17.3 hours. It completes its revolution around the Sun in 84 years time. Its speed is 7 kilometers.

4. Saturn

Fig 4. Saturn

Saturn is the second biggest and third fastest planet. It has a ring system. This ring system extends outwards up to 400,000 kilometers and each ring is almost 15 kilometers thick. The ring system of Saturn contains rock particles and dusty gases. Saturn has 18 moons except rings. Two of which, Titan and Escalades. They have atmosphere of Nitrogen gas. Titan and Escalades (moons of Saturn) show geological activities. One interesting thing about Titan(moon) is ,that it is larger than Mercury (Planet).It is distinguished from other Satellites by atmosphere which other satellites do not have. Its distance from the Sun is 1,427 million km. Its diameter is 120,000 km. It completes its rotation around its axis in 10 hours. It completes its revolution around the Sun in 29.5 years. Its speed is 10 km per second.

5. Jupiter

Fig.5 Jupiter

This is the 5th planet of the Sun. Its volume is greater than all other planets of the solar system. It is important to know that the mass of Jupiter is also heavier than the combined mass of all other planets. It is mainly composed of hydrogen and helium, which show that there might be a kind of reaction (fusion or fission) producing large amount of heat. This heat may have produced cloud bands and red soot. Jupiter has 16 satellites. It is 778.4million km away from the Sun. Its diameter is 142,800 kilometers. It revolves

around its axis and completes its rotation in 10 hours time. It completes its revolution around the Sun in 11.86 years. Its speed is 13 kilometer per second.

6. Mars

Fig.6 Mars

Have you ever read about the importance of Mars in Science magazines? Mars has been a sign of great interest for scientists and Gastronomists since a long time. Mars is considered smaller in size as compared to Earth and Venus. Carbon dioxide is present in its atmosphere. A great work has been done to find out the presence of Oxygen on Mars but no success in this respect. It surface contains rift valleys which show a kind of Geological activities which may have occurred almost two million years ago. Its surface looks red perhaps due to the presence of iron oxide. Mars has two moons. It is 228 million kilometers away from the sun. Its diameter is 6,790km. It completes its rotation around its axis in 24 hours. It completes its revolution around the Sun in 687 days. Its speed is 24 km per hour.

7. Earth

Fig.7 Earth

The place where we all live is also a part of our solar system. Earth is the largest and densest planet where life activities are going on. The presence of water and Oxygen is unique feature of this planet. Its atmosphere contains 21% free Oxygen, 78% Nitrogen, and .03-.04% Carbon dioxide It has one natural satellite, the Moon. It is 149.6 million kilometers far from the Sun. Its diameter is almost 12759 kilometers. It completes its rotation around its axis in 24 hours, and it completes its revolution around the Sun in 365.25 days. Its speed is 30 km per second.

8. Venus

Fig.8 Venus

Venus is often called twin of the Earth, because it is nearly equal to our Earth in size and volume. Internal geological activity has shown that its core is composed of iron while mantle is composed of silicate materials. It is much drier than Earth .Venus has no natural satellites. It is the hottest planet. The surface temperature of Venus is 400 °C. It is 108 million kilometers away from the Sun. Its diameter is 12,102 km. It completes its rotation around its axis in about 243 days. It completes its revolution around

the Sun in 225 days. It is the sole planet whose revolution and rotation are opposite in direction. While seeing from the Earth it is third luminous body after the sun and the moon. Its speed is 3 km per hour.

9. Mercury

Mercury is the nearest to the Sun and is 57.9 million kilometers away from the Sun. It is the smallest planet in the Solar System. Mercury has no natural satellite. It is interesting that being closest to the Sun it is less hot than Venus. The reason is that its atmosphere is very thick. Its temperature rises up to 500 C. It completes its revolution around the Sun in 88days. It rises almost along with the Sun and sets along with the sun.

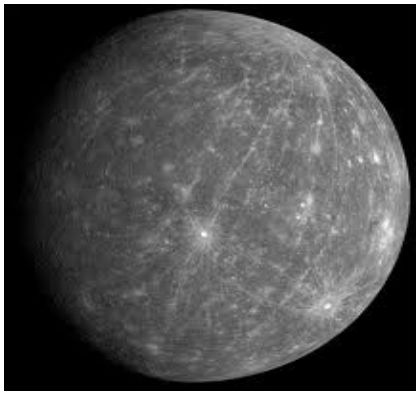

Fig.9 Mercury

The diameter of mercury is 4,880 kilometers. It rotates around its axis in 56.8 days. It is 57.9 million kilometers away from the Sun. Its speed is 48 km per hour. Its surface resembles to that of the surface of the Earth's moon.

Activity 1

What is the resemblance of our Solar System with the structure of an atom? Develop a model to support your arguments.

Key Points

1. Our solar system consists of The Sun, nine planets and some other bodies like moons and comets.
2. The names of nine planets are Pluto, Neptune, Uranus, Saturn, Jupiter, Mars, Earth, Venus and Mercury.
3. The Pluto is farthest planet and sometime not considered a planet. First it was a moon of Neptune. It completes its revolution around the sun in 248 years.
4. Neptune is smaller than Uranus. It radiates its internal energy but this energy is less than Jupiter and Saturn. Neptune has 13 moons. Its revolution time is 165 years.
5. Uranus is also a planet having very much colder core. It has 27 satellites. Its rotation time is 17.3 hours and revolution time is 84 years.
6. Saturn is the second biggest and third fastest planet. it has extensive ring system, which contain rock particles and dusty gases. Its rotation time is 10 hours and revolution time is 29.5 years.
7. The Jupiter is the most massive and bigger in size, mainly composed of hydrogen and helium. It has 16 satellites. Its rotation time is 10 hours and revolution time is 11.86 years.

8. Mars is smaller than earth, having atmosphere of carbon-dioxide. Its surface shows a kind of geological activities which have occurred 2 million years ago. its surface looks red due to the presence of iron oxide. Its rotation time is 24 hours and revolution time is 687 days.
9. Our earth is a only planet which have life activities. The presence of water and oxygen is a distinct feature of earth. Its rotation time is 24 hours and revolution time is 365.25 days.
10. Venus is also called twin of the earth but its surface is much drier. It has no natural satellites and is hottest planet.
11. Mercury is nearest to the sun having no natural satellite. Its revolution time is 88 days while its rotation time is 56.8 days. Its surface resembles to that of the surface of the earth's moon.

Self Assessment Exercise 2.2

Q.1 Fill in the blanks with correct words.

1. All Planets _____ around the sun.
2. The largest moon of Neptune is _____which is also geologically active.
3. Uranus has 27 moons and it completes its revolution around the sun in_____ time.
4. The planet _____ is mainly composed of hydrogen and helium.
5. The surface of Mars is mainly composed of _____, that's why Mars surface looks red.

Q.2. Choose the correct answer.

i. Which of the following planet has highest surface Temperature?
   a. Jupiter b. Mercury c. Pluto d. Saturn

ii. The following Planet has natural satellite except.
   a. Jupiter b. Uranus c. Neptune d. Venus

iii. Which one is in correct sequence from the Sun?
   a. Venus, mars, Saturn, Uranus b. Mars, Venus, Uranus, Saturn.
   c. Saturn, Venus, Mars, Uranus d. Venus, Saturn, Mars, Uranus.

Q3. Answer the following questions:

i. What is difference between a star and a planet? Write important characteristics of planets which belong to inner solar system?
ii. How our Solar System is important for further explorations, and why it has become necessary to explore the universe?

2.3 Theories of Origin of Earth

Before going to the theories let us understand what theory is? **A repeatedly tested or widely accepted statement is called theory. This statement is also used to make further predictions about a natural phenomenon.**

There are different theories about how earth was formed and no one theory can tell exactly how earth came into being. Scientists believe that the earth was formed more than 4 billion years ago. They found this by studying the radioactive elements contained in the rocks.

1. Creation theory or Mythical Theory

Muslims believe that our Earth and the whole universe is made by Almighty Allah. Christians also believe that the earth was made by God on seventh day. The Chinese believe that the earth was created by Pan Ku, a supernatural being.

An important man Anaximander suggested that the earth began from a ball of fire that covered a cold mass. When the ball of fire burst into pieces, these pieces became the bodies in space while the cold mass became the world.

2. Scientific theory

Scientists have better explanations, how earth came into being. These theories are based on long time studies, observations and researches made by expert scientists. Scientific theories have been developed by careful study of natural phenomenon and experimentations.

3. Tidal Theory

This theory was given by Sir James Jeans; an English mathematician and physicist.

According to him the earth was formed from materials pulled out from the sun. The theory explains that the Sun existed alone first, there came a wandering star near the Sun. The movement of the star created a tide that rose very high and it torn away some of the matter and gases from the suns outer layer. These matter and gases got together and formed bodies that became planets. Our earth is one of those planets.

4. Nebular Theory

This theory tells that how the sun and the planets were formed at the same time from a huge cloud of dust and gas floating in space. This material collapsed because of gravity and became a mass. With the passage of time the smaller mass begin to rotate and a disc was formed. There rotation caused a budge in the disc and this budge became hotter and hotter and energy was produced and shining (glow) started. This shining mass became the Sun and other smaller bodies became planets.

5. Solar Disruption Theory and Dynamic Encounter Theory

This theory was proposed by L. Buffon explains that 4or 4.5 billion years ago a star (comet) collided with the sun, causing some parts of the sun to burst. These parts became planets in the space.

6. Planetissimal Theory

The Planetissimal theory is similar to the Solar Disruption Theory in that the theory agrees that the planet s are formed when the Sun and another star almost collided in space which caused the Sun to burst out some hot materials that became parts of the star passing near the Sun. As the Sun continued to spew out materials, these became the planets and other objects in space.

7. Condensation Theory

According to this theory the stars came from mass of hydrogen gas and atomic dust. The stars burst out into pieces that became planets.

8. Big Bang Theory

About 10 to 20 billion year ago, the universe was packed into one giant fireball. Then an extraordinary explosion took place and expansion of the Universe started. This extraordinary explosion is termed as the Big Bang. This cosmic explosion spread matter and energy everywhere. This mass slowly became our Universe and the astronomical objects. The Big Bang theory was first proposed by Priest, George Lamaitre of Belgium**.** Since the Big Bang, the universe is continuously expanding and the distance between galaxies is ever increasing, since the time of explosion. This movement of galaxies away from each other is called **Red shift**. In 1964 cosmic radiations were discovered. After this discovery Scientists agreed that thermal radiations produced from black bodies were same to that of the cosmic rays. The spectrum of the both types of rays was found to be same. In this way most of the scientists were convinced by the fact that Big Bang must have occurred.

Key Points

1. A widely accepted statement which have been verified experimentally is called a theory.
2. Our Earth was formed more than 4 billion years ago.
3. The belief that our earth was formed by Almighty Allah on seventh day is called Creation or Mythical theory. A ball of fire was burst its pieces were scattered and space bodies were formed.
4. Tidal theory was proposed by Sir James Jean, which states that our Sun was alone first. A wandering star came near the sun and raised tides on the surface of the sun .these tides torn away and formed planets and our earth is one of them.
5. Nebular theory tells that the sun and planets were formed from a huge cloud of dust and gas floating in the space.
6. Solar disruption or Planetissimal theories tell that the sun and other planets were formed due the collision of the sun and another star.
7. According to this theory the stars came from mass of hydrogen gas and atomic dust. The stars burst out into pieces that became planets.
8. An extraordinary explosion took place about 10 to 20 billion years ago and expansion of the Universe started. This extraordinary explosion is termed as the Big Bang. This cosmic explosion spread matter and energy everywhere which ultimately became astronomical objects.

Self Assessment Exercise 2.3

Q.1 Fill in the blanks with correct words.

i. Our earth was formed about _____ years ago.
ii. Our earth was formed by _____is the belief of Chinese.
iii. The material collapsed due to gravity and became a mass. This statement is concerned with _____theory.

Q.2 Answer the following questions:

i. Write a note on tidal theory and Nebular theory.
ii. Which theory is liked by you the best, describe it and compare it with any other **theory?**
iii. Critically analyze the theories about the creations of the earth also give your suggestions.

Q.3 Choose the correct answers from the given options:

i. Scientists believe that our Earth was formed_____years ago.
   a. 4 trillion years ago
   b. more than 4 billion year ago
   c. Less than 4 billion years ago
   d. not known

ii. The theory proposed by Sir James jeans is.
   a. Scientific Theory
   b. Nebular theory
   c. Tidal theory
   d. Solar disruption theory

iii. Which radiations were discovered in 1964?

a. X-rays
b. Cathode rays
c. Alpha Rays
d. Cosmic rays

iv. Red Shift is

a. Movement of Galaxies towards each other.
b. Movement of Galaxies away from each other.
c. Movement of stars towards galaxies.
d. Movement of galaxies towards our solar system.

2.4 Earth and its Structure

The Earth was formed about 4.5 billion years ago. It was a big cloud of gases and dust, which gradually cooled down to the solid Earth. It took millions of years to cool down and taking the shape of present day Earth. In the beginning the molecular oxygen was not present but with the passage of time many reactions took place and many substances of atmosphere was formed. Apart from it, a series of volcanic eruptions took place releasing gases and water vapours .These gases and vapours also formed atmosphere. These water vapours accumulated in the atmosphere and condensed to form clouds and rains.

The water in the form of rains came to our Earth and was collected in hollows and deep places, and formed oceans. The surface structure of the earth continued to be changed due to the forces inside the Earth and hard crust was formed. The Crust split up into large blocks, called plates. Rocks were squeezed up to form new landmasses and mountains, when the plates pushed against each other. Plate movements continue today which sometimes causes earthquakes.

The Earth consists of three layers; viz Crust, Mantle and Core. Core is the innermost part of the earth, mostly consisted of molten iron. Surrounding the Core is a layer of molten rock called Mantle. The uppermost layer is called Earth's Crust. Every activity that we do, takes place on Earth's crust. The Crust is composed of many plates, called tectonic plates. Many persons believe that these plates float on the mantle and move and sometimes bump into each other causing shake. This shaking of plates is called Earthquakes. As we know, the Earth's surface is not all rock. The hydrosphere is the layer of water that covers 75% of the Earth's surface. And the atmosphere is the layer of the air above the surface that contains the Oxygen that supports life and also many other gases also.

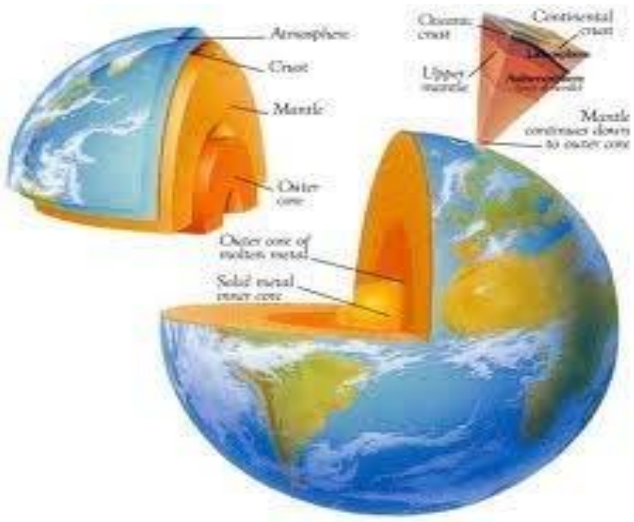

Fig.10 structure of earth

2.4.1 Motions of the Earth

The Earth is in constant motion, revolution of earth around the Sun and its rotation around its own axis. These motions result a number of consequences like occurrence of days and nights, changes in seasons and climates in different areas and regions. Movement of the Earth around its axis and around the Sun can be easily understood by mounting a globe and rotating it around its axis, and movement of the earth around the sun can be illustrated easily.

1. Rotation

If you see at the figure 11, it looks somewhat tilted. The Earth completes its rotation in the time of one day. Rotation is also called spinning .The Earth spins around its axis from West to East. Rotation of the earth cause days and nights, the rate of rotation is approximately 1,038 miles per hour, decreasing to zero at the poles. Tilting of earth causes occurrence of different seasons.

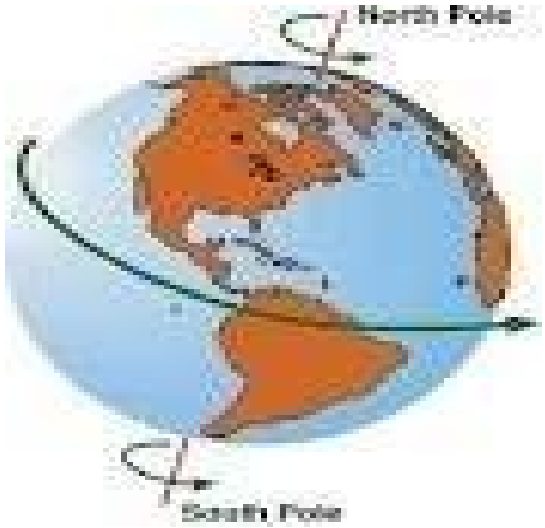

Fig.11 Rotation of Earth

2. Revolution

The motion of the Earth around the Sun is called revolution. Earth completes its revolution around the sun in the time of one year. The path on which earth revolves is called Earth's orbit. It is nearly an elliptical path. The mean distance of the Earth from the Sun is about 93million miles and the distance varies by 3 million miles, forming a slightly elliptical path.

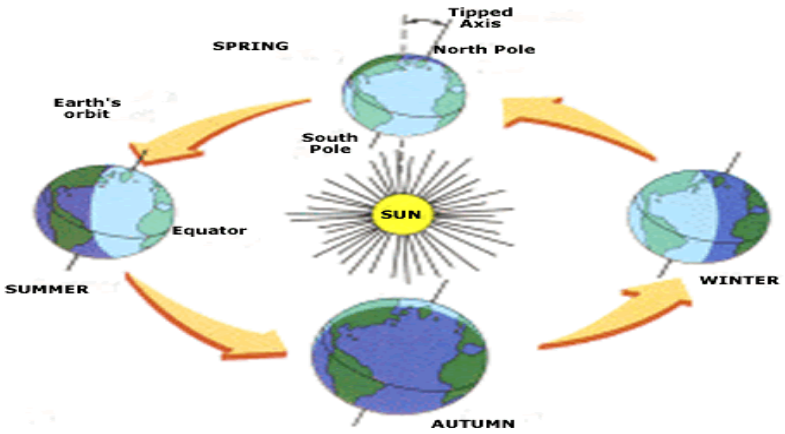

Fig.11. Revolving earth

The revolution of the Earth around the Sun travels a distance of 595 million miles in 365 days, 6 hours, 9 minutes and 9.5 seconds. This means that average speed of the earth is 18 miles a second.

3. Influence of the Sun and the Moon on Earth

The sun influences the earth in many ways. The Sunlight, warmth, and the chronology are the influences of the Sun, whereas moon has its own influences on the earth .They are gravity and its motion.

The moon orbits the earth due to the gravity of the earth. The moon also have gravitational power but moon's gravity is 1.6 where as the gravity of the earth is $10m/s^2$. By the way gravity pulls the Earth and Moon toward each other. Tides are caused (high tide and low tide) due to the gravity of the moon. The sun also has some influence here. The sun brings light and is also responsible for the warming up of the earth.

Activity 2

Prepare a model of Earth showing its different layers.

2.4.2 The Lithosphere

The uppermost layer of the earth where we live is a part of the Lithosphere. Lithosphere is composed of the earth's crust and upper mantle. It is called rock sphere. It extends up to the depth of 100 km.

The mass of lithosphere is composed of 11 elements. They are oxygen, silicon, Aluminium, iron, calcium, sodium, potassium, magnesium, titanium, hydrogen and phosphorous. Some elements occur in the form of minerals.

Lithosphere can easily move on the molten mass of mantle. This molten mass resembles to that of the plastic. This movement affects the earth's crust .It affects heat transport through the Earth. Under the lithosphere there is the Astheno-sphere, the weaker, hotter and deeper part of the upper mantle.

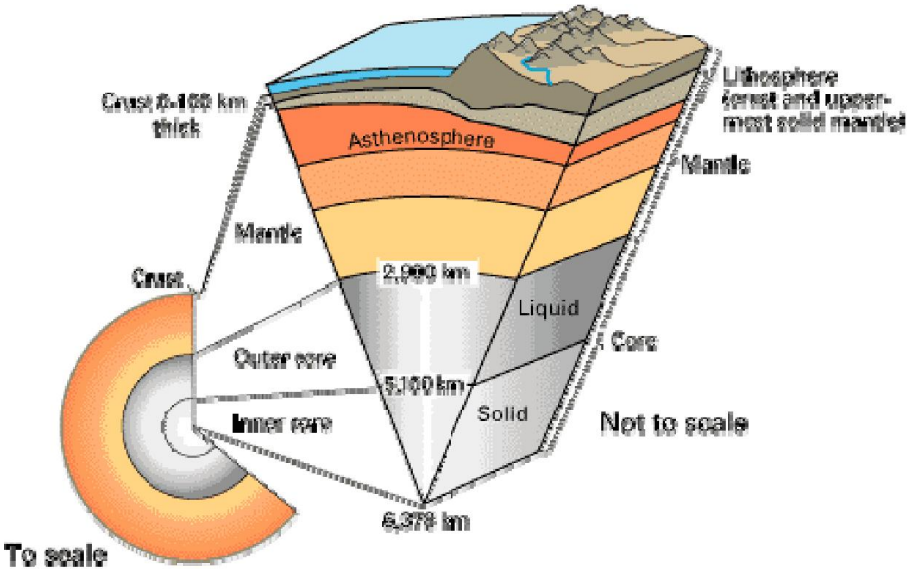

Fig.12. The Lithosphere of earth

1. Types of Lithosphere

What do you see generally when you take a glance at the surface of the earth. At most of the places there are oceans and at some places there is land portion called continental part.

1. Oceanic lithosphere, which is associated with Oceans and exists in the ocean basins Oceanic lithosphere is 50-100 kilometers thick.
2. Continental lithosphere, which is associated with Continental crust. It is 40-200 kilometers thick

The **continental crust** is the layer of igneous, sedimentary, and metamorphic rocks which form the continents and the areas of shallow sea bed close to their shores, known

as continental shelves. This layer is sometimes called *sial* because there is more granite rocks, and *sima* because of the basalt rock.

Consisting mostly of granitic rock, continental crust has a density of about 2.7 g/cm^3 and is less dense than the material of the Earth's mantle, which consists of mafic rock. Continental crust is also less dense than oceanic crust (density of about 3.3 g/cm^3), though it is considerably thicker; mostly 25 to 70 km versus the average oceanic thickness of around 7–10 km. About 40% of the Earth's surface is now underlain by continental crust. Continental crust makes up about 70% of the volume of Earth's crust.

Fracis Bacon a famous English geologist first of all presented a model of world map and said that all continents were concentrated at one place. Wegner called this part of as Pangaea, which means the all earth. This theory is called Continental Drift Theory. After that this big continent was broken down into two parts. The Northern part was named an Laurasia having northern America, Europe and Asia while Southern part was named as Gondwana having south America north Africa.

Indian pacific Australia and Intarctica. A strongest argument which was given by Wegner to support continental Drift was that if all continents are put together they fit together as it were a single one. But still the actual reason of Continental Drift have never been found. In 1980 geologists have divided the tectonic plates into seven plates. These seven plates are given the names of seven Continents. These continental plates are in motion, and their motion can be divided into three types which are as under; Convergent or collision, Divergent or spreading and transform movements of plates.

2.4.3 Hydrosphere

A **hydrosphere** is a Greek word; *hydro means* "water" and **-** *sphaira* means "sphere". Hydrosphere is the total mass of water found on, under, and over the surface of a planet. The hydrosphere includes all water bodies, mainly oceans, rivers, streams, lakes, polar ice caps, glaciers and ground water. Oceans contain 97% of earth's water. The polar ice caps and glaciers consist of 2% of the earth's total water supply. The total mass of the Earth's hydrosphere is about 1.4×10^{18} tons, which is about 0.023% of the Earth's total mass. Only 1% of the total water resources are available as fresh water.

2.4.4 Hydrological Cycle

Water is not found only in oceans, lakes, rivers and underground water. But most of the water is found in ice and vapours form. Have you ever think how rains occur and how clouds are formed. As you have read in chemistry that evaporation is caused due to Sun light and heat, from all reservoirs water resources including oceans, rivers, lakes, soil and the leaves of plants. **Evaporation is a process of conversion of liquid (water) into vapour (gases) form**. Water vapour is further released as transpiration from plants and humans and other animals. Also the evaporation helps the plants receive water (H2O) from the soil. **The movement of water around, over, and through the Earth is called the water cycle. Water cycle is a key process of the hydrosphere.**

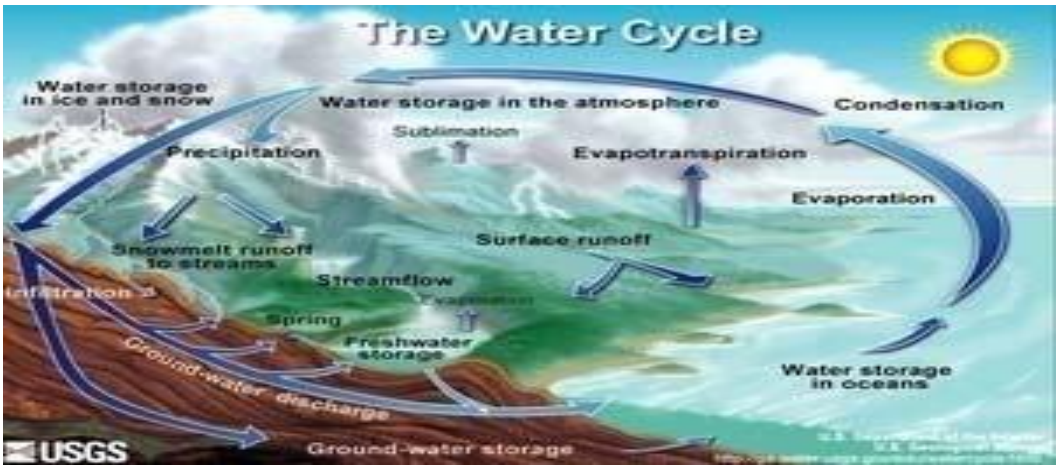

Fig.13 Hydrological Cycle

Water -cycle is of much importance because water- cycle makes our atmosphere clean from pollutants (harmful materials that enter in air due to human activities). Secondly water cycle is a good source of clean water. It is obvious that most of the water of hydrosphere is salty and is unfit for drinking purposes. Water cycle causes rain which is ultimately beneficial for the growth of crops.

2.4.5 The Earth's Atmosphere, Availability of Oxygen and the Ozone layer

1. The Atmosphere

The place all around our earth where we breathe is called atmosphere. This layer around the earth is a colourless, odourless, tasteless 'sea' of gases, water and fine dust. The earth is surrounded by gases. Without atmosphere life on earth is not possible. The atmosphere gives us air, water, warmth and is protecting us against harmful rays of the sun and against meteorites. The Troposphere is the layer where the weather happens; above this layer is the Stratosphere. Within the Stratosphere is the Ozone layer that absorbs the Sun's harmful ultraviolet rays. Above the Stratosphere is the Mesosphere, the Thermosphere - in which the Ionosphere - and the Exosphere. The atmosphere is about 500 miles (800 km) thick.

Fig.14 the Atmosphere

The atmosphere becomes thinner and thinner with increasing altitude, with no definite boundary between the atmosphere and the outer space. Air is the name given to atmosphere used in breathing and photosynthesis. Dry air contains roughly (by volume) 78.09% nitrogen, 20.95% oxygen, 0.93% argon, 0.039% carbon dioxide, and small amounts of other gases. Air also contains a variable amount of water vapor, on average around 1%. While air content and atmospheric pressure varies at different layers, air suitable for the survival of terrestrial plants and terrestrial animals is currently only known to be found in Earth's troposphere and artificial atmospheres.

2. Composition of Earth's Atmosphere

The major part of the atmosphere is occupied by air. Nitrogen, oxygen, and argon, which together constitute the major gases of the atmosphere. The remaining gases are often referred to as trace gases, among which are the greenhouse gases such as water vapour, carbon dioxide, methane, nitrous oxide, and ozone. Many substances like dust, pollen and spores, spray, and volcanic ash are also found in air. Various industrial pollutants such as chlorine, fluorine compounds, elemental mercury, and sulfur compounds such as sulfur dioxide (SO2) are also a part of atmosphere.

3. Composition of dry atmosphere, by volume

Composition of different gases in air is given in the table as under.

Gas	Volume	Gas	Volume
Nitrogen (N_2)	78%	Nitrous oxide	0.00003%
Oxygen (O_2)	20.946%	Carbon monoxide	0.00001%
Argon (Ar)	0.9340%	Xenon (Xe)	0.000009%
Carbon dioxide (CO_2)	0.039%	Ozone (O_3)	0 to 7×10^{-6}%)
Neon (Ne)	0.001818%	Iodine (I_2)	0.000001%
Helium (He)	0.000524%	Nitrogen dioxide	0.000002%
Methane (CH_4)	0.000179%	Ammonia (NH_3)	Trace
Krypton (Kr)	0.000114%	Not included in above dry atmosphere:	
Hydrogen (H_2)	0.000055%	Water vapor (H_2O)	0.40% over full atmosphere, typically 1%-4% at surface

4. Ozone Layer

The **ozone layer** is mainly composed of tri molecular oxygen ($O_{3)}$ .This layer absorbs 97–99% ultraviolet rays of the light, which are harmful for human and other forms of life. It is mainly located in the lower portion of the stratosphere from approximately 20 to 30 kilometers above Earth. The thickness of ozone layer is different at different places.

The ozone layer was discovered in 1913 by the French physicists Charles Fabry and Henri Buisson.

Ozone - Oxygen Cycle in the Ozone Layer

The photochemical mechanisms that give rise to the ozone layer were discovered by the British physicist Sidney Chapman in 1930. Ultraviolet rays break the oxygen molecule into atomic oxygen (O). This atomic oxygen is most reactive and combine with O_2 to give O_3.O_3 is ozone molecule. Again ozone is also unstable and breaks up into O_2 and (O). In this way ozone-oxygen cycle continues.

About 90% of the ozone in our atmosphere is present in the stratosphere. Ozone concentrations are greatest between 20 and 40 kilometers. If all of the ozone were compressed to the pressure of the air at sea level, it would be only 3 millimeters thick.

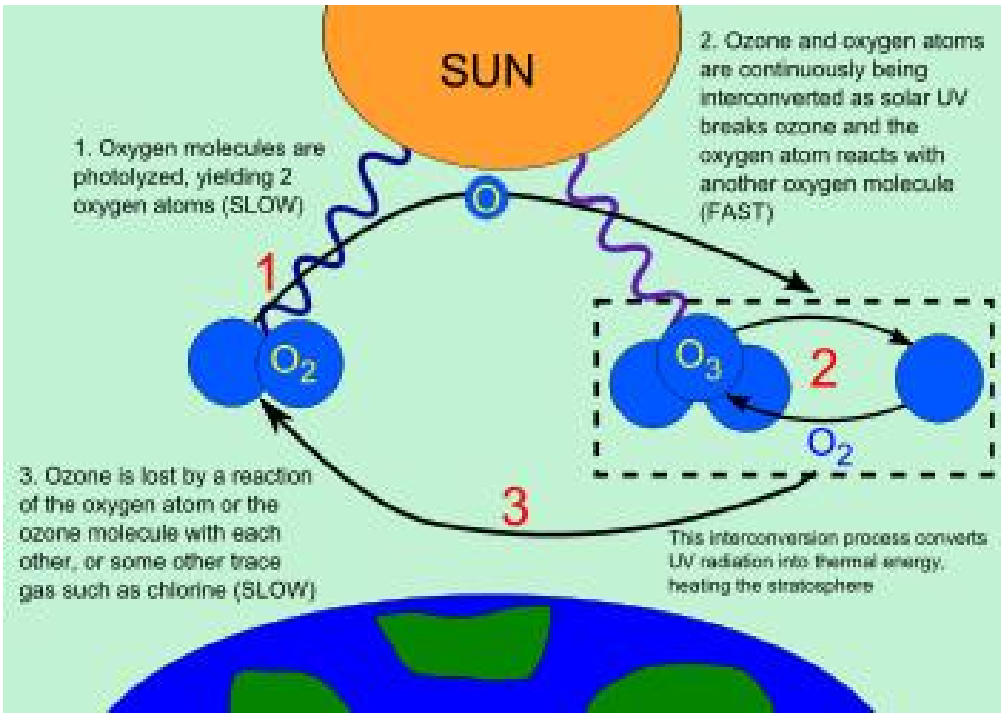

Fig.15 Ozone Oxygen Layer

Ozone Depletion a Big Issue or Problem

The chlorofluouro carbons released by manmade appliances and reach stratosphere where chlorine and Bromine ions are released due to the action of ultraviolet rays. These radical are so dangerous that it can breakdown 100,000 ozone molecules. The broken molecules of ozone are unable to absorb the ultraviolet radiations.

Ultimately unabsorbed and dangerous ultraviolet-B radiation is able to reach the Earth's surface. Ozone levels over the northern hemisphere have been dropping by 4% per decade.

Over approximately 5% of the Earth's surface, around the north and south poles, much larger seasonal declines have been seen, and are described as ozone holes. In 2009, nitrous oxide (N_2O) was the largest ozone-depleting substance emitted through human activities.

Regulation

In 1978, the United States, Canada and Norway banned on CFC-containing aerosol sprays that are thought to damage the ozone layer. In the U.S., chlorofluorocarbons continued to be used in other applications, such as refrigeration and industrial cleaning, until after the discovery of the Antarctic ozone hole in 1985. The CFC production was limited in 1987. On August 2, 2003 scientists told that ozone depletion has been reduced due to ban on CFC.. Three satellites and three ground stations confirmed that the upper atmosphere ozone depletion rate has slowed down significantly during the past decade. The study was organized by the American Geophysical Union.

CFCs have very long atmospheric lifetimes, ranging from 50 to over 100 years, so the final recovery of the ozone layer is expected to require several lifetimes.

Compounds containing C–H bonds (such as hydro chloro-fluorocarbons, or HCFCs) have been designed to replace the function of CFCs.

These HCFCs are being replaced by CFCs because HCFCs are less damaging than CFCs.

Impacts of Atmosphere on the Earth

Atmosphere has many direct and indirect impacts on the life. Some of them are described as under.

Favourable Temperature

Our atmosphere has capacity to absorb, emit and scatter the radiations, and hence keep the temperature constant. This constant temperature is very essential for sustenance of life.

Earth's Guard

Atmosphere is the guard of our earth in a sense that it keeps our earth safe from harmful effects of ultraviolet radiations and x-rays coming from the Sun. Second it meteorites burns before reaching our earth, otherwise it can cause craters and many kinds of disturbances in life activities.

Basis for Different Cycles

Atmosphere interacts with hydrosphere and lithosphere and exchange of materials take place among them. Cycles of gases and water are are going on the atmosphere which are necessary for life. In this way a biological ecosystem is maintained on the earth.

Basis for Different Phenomenon

Dispersion of sound is due to atmosphere, as sound does not travel in vacuum. Sky looks blue twinkling of stars, brightening of the moon are seen from the earth, are due to the Earth's atmosphere.

Radio Links and Broadcasting

In Stratosphere another sub layer is found which is called D-layer at the height of 80 to 85 kilometers .This layer reflects the Radio-waves on the earth which causes radio-links and broadcasting at far of places of the earth at one time.

Activity 3

List down some steps that you will take if you are asked for a campaign for protection of our atmosphere.

Key Points

1. Lithosphere is composed of the earth's crust and the upper mantle, having depth about 100 km.
2. Lithosphere is composed of eleven elements, which are oxygen, silicon, Aluminum, iron, calcium, sodium, magnesium, titanium, hydrogen, and phosphorous.
3. Below the litho-sphere is a plastic like molten mass on which Litho-sphere floats.
4. There are two types of Lithosphere. One is Oceanic and the other is continental Lithosphere.
5. Lithosphere is divided into seven tectonic plates, which are named as seven continents.
6. Hydrosphere is the total mass of water on/in the earth.
7. Oceans contain a big part of water, which is 97% of the total water of the earth.
8. Glaciers contain 2% of the total water of the hydrosphere.
9. Only 1% of the total hydrosphere is available as fresh water which is used for drinking and crop production.
10. The movement of water from one place and this form to another place and this form is called water cycle.
11. Conversion of water from liquid form to vapour form at ordinary temperature is called evaporation.
12. Evaporation cause cooling and also form clouds which may cause rain.
13. Rain is one of the processes of purification of water.
14. A layer all around Our Earth which mainly consist of air, dust particles and water vapours.
15. Air consists of many gases like Oxygen, nitrogen, Carbondioxide, Argon and many other trace gases.
16. Atmosphere consists of four layers namely troposphere, Stratosphere, Mesosphere and Thermosphere.
17. Ozone is a molecule consisting of three atoms of Oxygen.
18. Ozone layer is present 31 kilometers above the earth's surface. Ozone layer is a part of Stratosphere.
19. Nitrogen is 78% whereas Oxygen is 21% in the earth's atmosphere.
20. Our earth has to pass a series of changes to get the present position, like one volcanic eruptions which released gases and water vapours which ultimately formed atmosphere.
21. Earthquakes occur due to the movement of tectonic plates.
22. Our earth consists of three layers Crust, Mantle and Core.
23. Our earth is 3 parts water and one part land.
24. Our earth is a planet and moves around the sun. This movement is called revolution
25. Our earth spins around its axis. This movement is called rotation.
26. Rotation cause days and nights, whereas revolution causes seasons and climatic changes.
27. Our earth attracts other bodies with a force. This force is called gravity of the earth.

Self Assessment Exercise 2.4

Q.1 Fill in the blanks with correct words.

i. The earth's_____ consists of many plates called tectonic plates.
ii. The earth completes its rotation in _____hours time.
iii. Days and nights are caused by _____of the earth.
iv. Our earth has _____ layers.
v. Average speed of earth is _____miles per second.

Q.2 Choose the correct answer.

i. Shaking of plates causes.
   a. Storm. B. Earthquake. C. Hurricane d. Revolution.

ii. The earth spins around its axis from.
   a. East to West. b. West to East. c. North to South.
   d. South to North.

iii. Which of the following factors explain why Earth can support lives?
   1. It has air. 2. It has water 3. It has a large surface.
   4. It has a suitable temperature.

Choose your answer from the following options.

a. 1 and 3 B. 1, 3 and 4 c. 2 and 4. D. All 1,2,3 and 4.

iv. The _____ crust is a layer made up of igneous, sedimentary and metamorphic rocks.
   a. Oceanic b. Continental. c. Mafnic. d. Core.

v. Once our earth was a single mass, which broke into two pieces . This is supported by a theory.
   a. Planetissimal. b. Continental Drift. c. Oceanic slip.
   d. Creational.

vi. Lithosphere can be up to _____ kilometers thick.
   a. 5. b. 35 c. 65. D. 100

vii. Atmosphere is made up of.
   a. Mixture of gases. b. Gases, solids and liquid particles.
   c. Only water vapours. d. Molecular Nitrogen and Oxygen.

viii. The region of atmosphere immediately above the surface of the earth is.
   a. Lithosphere. b. Troposphere. c. Stratosphere.
   d. Biosphere.

ix. We can see clouds in the region of atmosphere.

a. Troposphere b. Stratosphere. c. Thermosphere.
d. Mesosphere.

x. Ozone layer occurs in the layer.
a. Troposphere. b. Stratosphere. c. Mesosphere.
d. Thermosphere

xi. Earth is protected from UV radiations by means of.
a. Nitrogen b. Ozone layer. c. Carbon-dioxide.
d. Stratosphere.

xii. Which gas holds the UV rays?
a. O_2 b. N_2 c. O_2 d. CO_2

xiii. Which one is the most abundant gas in the atmosphere?
a. Oxygen. b. Hydrogen. c. Nitrogen. d. Water vapors.

Q.3 Answer the following questions:

What do you know about the rotation and revolution of the earth?

i. Write series of changes which took place on earth to give it present shape.
ii. What is difference between the gravity of earth and the Gravity of the Moon?
iii. Define Lithosphere?
iv. Explain the types of Lithosphere.
v. How lithosphere is important for us?
vi. Define hydrosphere?
vii. Hydrosphere is the big part of our earth Elaborate.
viii. Draw water cycle. Also write its importance.
ix. Define Atmosphere? Also write composition of Earth's atmosphere.
x. What is Ozone and why is it important?
xi. Explain Ozone-Oxygen Cycle in the Stratosphere.
xii. Explain the importance of oxygen and ozone layer for life activities. What would happen if there was no ozone layer?

2.5 The Galaxies

A galaxy is a group of Stars and solar systems. A galaxy is so vast that it contains millions of stars. There is a number of galaxies present in our universe. A galaxy has a distinct shape, and shape depend upon the arrangement of the stars. There is one hundred thousand galaxies known to us.

Galaxies come in four main types: Ellipticals, Spirals, Barred and Irregular. Galaxies are grouped together to form Clusters

2.5.1 Elliptical Galaxies

Elliptical Galaxies are the largest known galaxies. They are circular (Ellipsoidal), long, narrow or cigar shaped. They have relatively little inter-stellar matter. Elliptical galaxies are often made up of upto 1 trillion older stars. The formation of new stars is very rare due to less amount of dust and gases. This galaxy looks red due to red coloured stars. Most stars remain close to each other due to forces of gravitation. They do not have black holes.

Fig. 16 Elliptical galaxies

2.5.2 Spiral Galaxies

The name spiral is given due to the long thin elongations (arms) extending from the centre. Spiral galaxies consist of a rotating disk of, and a central bulge of generally older stars. Extending outward from the bulge are relatively bright arms. These galaxies are rich in dust and gas. In spiral arms stars are formed actively. Spiral galaxies are composed of millions of older stars in the center while arms have new stars. They also have black holes.

Fig.17 Spiral Galaxies

Like the stars, the spiral arms rotate around the center, but they rotate with constant angular velocity. The spiral arms contain high density matter. As stars move through an arm, the velocity of each stellar system is changed by the gravitational force of the higher density.

The arms are visible because of star formation, and have many bright and young stars.

Fig.18 Formation of Spiral galaxies

A majority of spiral galaxies have a linear, bar-shaped band of stars that extends outward to either side of the core, then merges into the spiral arm structure.

Bars are temporary structures formed from density wave of the core.

The galaxy of which our solar system is a part of is large disk-shaped barred spiral galaxy. It has two hundred billion stars. Its total mass is six hundred billion times greater than the mass of the sun.

2.5.3 Irregular Galaxies

These Galaxies has no definite shape. The Stars in an irregular galaxy do not appear to be grouped in any set shape. These Galaxies have many shapes and sizes. The clouds of Magellan, is an irregular Galaxy. It is very small Galaxy near the Milky Way. These Galaxies are not very common.

Fig.19 Irregular Galaxies

2.5.6 The Milky Way Galaxy

On a dark night have you ever seen a band of lights stretched on the sky? This is called a milky way. The milky-way is composed of faint stars. The proof of the Milky Way consisting of many stars came in 1610 when Galileo used a telescope to study the Milky Way and discovered that it is composed of a huge number of faint stars.

Fig.20 Milky way Galaxy

Our solar system is considered to be present at the center of the milky-way galaxy. The first attempt to describe the shape of the Milky Way and the position of the Sun in it was carried out by William Herschel in 1785 by carefully counting the number of stars in different regions of the sky.

He produced a diagram of the shape of the galaxy with the solar system close to the center.

Key Points

1. A Galaxy is a group of Solar systems which contain millions of stars.
2. There are four main types of galaxies, Elliptical, Spiral, Barred and Irregular.
3. Elliptical galaxy is the largest known galaxy which contains one trillion older stars. New stars are formed very rare. It looks red and stars remain close to each other.
4. In these Galaxy long thin arms extends from the center. These consist of a rotating disc which contains older stars in the center and new stars in the arms.
5. Irregular galaxies has no regular shape. They are not very common.
6. Milky way Galaxies are well known as our solar system is present in the center of milky way. A milky way contain a huge number of faint stars.
7. Elliptical galaxies do not have black holes whereas Spiral galaxies have black holes.
8. A Black Hole is black because nothing can escape it as it has very strong density.

Self Assessment Exercise 2.5

Q.1 Pick the correct answers.

i. The milky way galaxy is
   a. considered a small cluster of stars.
   b. A spiral galaxy is similar to the Andromeda galaxy
   c. Composed of between 100 million and 200 million stars
   d. The largest galaxy in the universe.

ii. The center of our Milky Way Galaxy
   a. Contains a very large Sun.
   b. Is believed to contain a massive black hole.
   c. Contains hundreds of stars similar to our sun.
   d. Is a large empty hole.

iii. The age of the Milky Way galaxy is
   a. The same as the age of our sun
   b. About 5 billion years old.
   c. About 13.5 billion years old.
   d. About 25 billion years old.

iv. What is believed will be the final stage of our Sun's life?
   a. red giant. b. white dwarf.
   c. neutron dwarf. d. pulsar

v. Which type of galaxy have a clearly defined disk component.
   a. ellipitical b. irregular
   c. Spirals only d. Spirals and lenticulars.

Q.2 Answer the following questions:

i. Define a Galaxy, also write its main types.
ii. Define a milky way. Discuss different types of Milky ways.

2.6 The Black Holes

1. What is a black hole?

Dear students, you might have seen the working of a vacuum cleaner. When you do, watch closely because you will see the dirt and crumbs start to move towards the vacuum cleaner. A black hole is similar to a vacuum cleaner, cleaning up debris left behind in outer space.

However, it is not suction power that makes things fall into a black hole. Suction would not be strong enough. Instead, a black hole uses the power of gravity to pull things towards it.

A black hole is defined by the escape velocity that would have to be attained to escape from the gravitational pull exerted upon an object. For example, the escape velocity of earth is equal to 11 km/s. Anything that wants to escape earth's gravitational pull must go at least 11 km/s, no matter what the thing is — a rocket ship or a baseball. The escape velocity of an object depends on how compact it is; that is, the ratio of its mass to radius. A black hole is an object so compact that, within a certain distance of it, even the speed of light is not fast enough to escape.

2. How is a stellar black hole created?

Now question arises: How do black holes form? The answer is as follows:
When a large star runs out of fuel it can no longer support its heavy weight. The pressure from the star's massive layers of hydrogen press down forcing the star to get smaller and smaller and smaller. Eventually the star will get even smaller than an atom. Imagine that for a moment, an entire star squashed up into less space than a tiny atom.

This is a common type of black hole which is produced by some dying stars. A star with a mass greater than 20 times the mass of our Sun may produce a black hole at the end of its life. In the normal life of a star there is a constant tug of war between gravity pulling in and pressure pushing out. Nuclear reactions in the core of the star produce enough energy to push outward. For most of a star's life, gravity and pressure balance each other exactly, and so the star is stable. However, when a star runs out of nuclear fuel, gravity gets the upper hand and the material in the core is compressed even further. The more massive the core of the star, the greater the force of gravity that compresses the material, collapsing it under its own weight. For small stars, when the nuclear fuel is exhausted and there are no more nuclear reactions to fight gravity, the repulsive forces among electrons within the star eventually create enough pressure to halt further gravitational collapse. The star then cools and dies peacefully. This type of star is called the "white dwarf." When a very massive star exhausts its nuclear fuel it explodes as a supernova. The outer parts of the star are expelled violently into space, while the core completely collapses under its own weight.

3. How can something get smaller but retain the same amount of mass, or stuff?

It is really quite simple. If you take a sponge the size of a soda can, you can easily squish it in your hands until it is completely covered. But here is the interesting part. If you make something smaller by squishing it, its gravity becomes much stronger. Imagine then, if you squish a star into the size of an atom how powerful its gravity would become.

A black hole's gravity becomes so powerful that anything, including light that gets too close, gets pulled in. That's right, not even light can escape the grasp of a black hole.

4. Since light has no mass how can it be trapped by the gravitational pull of a black hole?

Newton thought that only objects with mass could produce a gravitational force on each other. Applying Newton's theory of gravity, one would conclude that since light has no mass, the force of gravity couldn't affect it. Einstein discovered that the situation is a bit more complicated than that. First he discovered that gravity is produced by a curved space-time. Then Einstein theorized that the mass and radius of an object (its compactness) actually curves space-time. Mass is linked to space in a way that physicists today still do not completely understand. However, we know that the stronger the gravitational field of an object, the more the space around the object is curved. In other words, straight lines are no longer straight if exposed to a strong gravitational field; instead, they are curved. Since light ordinarily travels on a straight-line path, light follows a curved path if it passes through a strong gravitational field. This is what is meant by "curved space," and this is why light becomes trapped in a black hole. In the 1920's Sir Arthur Eddington proved Einstein's theory when he observed starlight curve when it traveled close to the Sun. This was the first successful prediction of Einstein's General Theory of Relativity.

One way to picture this effect of gravity is to imagine a piece of rubber sheeting stretched out. Imagine that you put a heavy ball in the center of the sheet. The weight of the ball will bend the surface of the sheet close to it. This is a two-dimensional picture of what gravity does to space in three dimensions. Now take a little marble and send it rolling from one side of the rubber sheet to the other. Instead of the marble taking a straight path to the other side of the sheet, it will follow the contour of the sheet that is curved by the weight of the ball in the center. This is similar to how the gravitation field created by an object (the ball) affects light (the marble).

5. Anatomy of a Black Hole

Black holes are made up of 3 main parts. The very outer layer of a black hole is called the *Outer Event Horizon*. Within the Outer Event Horizon you would still be able to escape from a black hole's gravity because the gravity is not as strong here.

The middle layer of a black hole is called the *Inner Event Horizon*. If you didn't escape the black hole's gravity before you entered the Inner Event Horizon, then you have missed your chance to escape. The gravity in this layer is much stronger and does not let go of objects it captures. At this point you would begin to fall towards the center of the black hole. The center of a black hole is called the *Singularity*. This is simply a big word that means squashed up star. The Singularity is where the black hole's gravity is the strongest.

6. What does a Black Hole look like?

A black hole itself is invisible because no light can escape from it. In fact, when black holes were first hypothesized they were called "invisible stars." If black holes are invisible, how do we know they exist? This is exactly why it is so difficult to find a black hole in space! However, a black hole can be found indirectly by observing its effect on the stars and gas close to it. For example, consider a double-star system in which the stars are very close. If one of the stars explodes as a supernova and creates a black hole, gas and dust from the companion star might be pulled toward the black hole if the companion wanders too close. In that case, the gas and dust are pulled toward the black hole and begin to orbit around the event horizon and then orbit the black hole. The gas becomes heavily compressed and the friction that develops among the atoms converts the kinetic energy of the gas and dust into heat, and x-rays are emitted. Using the radiation coming from the orbiting material, scientists can measure its heat and speed. From the motion and heat of the circulating matter, we can infer the presence of a black hole. The hot matter swirling near the event horizon of a black hole is called an accretion disk.

7. Do all stars become Black Holes?

Only stars with very large masses can become black holes. Our Sun, for example, is not massive enough to become a black hole. Four billion years from now when the Sun runs out of the available nuclear fuel in its core, our Sun will die a quiet death. Stars of this type end their history as white dwarf stars. More massive stars, such as those with masses of over 20 times our Sun's mass, may eventually create a black hole. When a massive star runs out of nuclear fuel it can no longer sustain its own weight and begins to collapse. When this occurs the star heats up and some fraction of its outer layer, which often still contains some fresh nuclear fuel, activates the nuclear reaction again and explodes in what is called a supernova. The remaining innermost fraction of the star, the core, continues to collapse. Depending on how massive the core is, it may become either a neutron star and stop the collapse or it may continue to collapse into a black hole. The dividing mass of the core, which determines its fate, is about 2.5 solar masses. It is thought that to produce a core of 2.5 solar masses the ancestral star should begin with over 20 solar masses. A black hole formed from a star is called a stellar black hole.

8. How many types of black holes are there?

According to theory, there might be three types of black holes: stellar, supermassive, and miniature black holes — depending on their size. These black holes have also

formed in different ways. Stellar black holes are described in Question 6. Supermassive black holes likely exist in the centers of most galaxies, including our own galaxy, the Milky Way. They can have a mass equivalent to billions of suns. In the outer parts of galaxies (where our solar system is located within the Milky Way) there are vast distances between stars. However, in the central region of galaxies, stars are packed very closely together. Because everything in the central region is tightly packed to start with, a black hole in the center of a galaxy can become more and more massive as stars orbiting the event horizon can ultimately be captured by gravitational attraction and add their mass to the black hole. By measuring the velocity of stars orbiting close to the center of a galaxy, we can infer the presence of a supermassive black hole and calculate its mass. Perpendicular to the accretion disk of a supermassive black hole, there are sometimes two jets of hot gas. These jets can be millions of light years in length. They are probably caused by the interaction of gas particles with strong, rotating magnetic fields surrounding the black hole. Observations with the Hubble Space Telescope have provided the best evidence to date that supermassive black holes exist.

The exact mechanisms that result in what are known as miniature black holes have not been precisely identified, but a number of hypotheses have been proposed. The basic idea is that miniature black holes might have been formed shortly after the "Big Bang," which is thought to have started the Universe about 15 billion years ago. Very early in the life of the Universe the rapid expansion of some matter might have compressed slower-moving matter enough to contract into black holes. Some scientists hypothesize that black holes can theoretically "evaporate" and explode. The time required for the "evaporation" would depend upon the mass of the black hole. Very massive black holes would need a time that is longer than the current accepted age of the universe. Only miniature black holes are thought to be capable of evaporation within the existing time of our universe. For a black hole formed at the time of the "Big Bang" to evaporate today its mass must be about 10^{15}g (i.e., about 2 trillion pounds), a little more than twice the mass of the current *Homo sapien* population on planet Earth. During the final phase of the "evaporation," such a black hole would explode with a force of several trillion times that of our most powerful nuclear weapon. So far, however, there is no observational evidence for miniature black holes.

9. When were black holes first theorized?

Using Newton's Laws in the late 1790s, John Michell of England and Pierre LaPlace of France independently suggested the existence of an "invisible star." Michell and LaPlace calculated the mass and size — which is now called the "event horizon" — that an object needs in order to have an escape velocity greater than the speed of light. In 1967 John Wheeler, an American theoretical physicist, applied the term "black hole" to these collapsed objects.

10. What evidence do we have for the existence of black holes?

Astronomers have found convincing evidence for a super massive black hole in the center of the giant elliptical galaxy M87, as well as in several other galaxies. The

discovery is based on velocity measurements of a whirlpool of hot gas orbiting the black hole. In 1994, Hubble Space Telescope data produced an unprecedented measurement of the mass of an unseen object at the center of M87. Based on the kinetic energy of the material whirling about the center (as in Wheeler's dance, see Question 4 above), the object is about 3 billion times the mass of our Sun and appears to be concentrated into a space smaller than our solar system.

For many years x-ray emission from the double-star system Cygnus X-1 convinced many astronomers that the system contains a black hole. With more precise measurements available recently, the evidence for a black hole in Cygnus X-1 is very strong.

11. How does the Hubble Space Telescope search for black holes?

A black hole cannot be viewed directly because light cannot escape it. Effects on the matter that surrounds it infer its presence. Matter spinning around a black hole heats up and emits radiation that can be detected. Around a stellar black hole this matter is composed of gas and dust. Around a super massive black hole in the center of a galaxy the swirling disk is made of not only gas but also stars. An instrument aboard the Hubble Space Telescope, called the Space Telescope Imaging Spectrograph (STIS), was installed in February 1997. STIS is the space telescope's main "black hole hunter." A spectrograph uses prisms or diffraction gratings to split the incoming light into its rainbow pattern. The position and strength of the line in a spectrum gives scientists valuable information. STIS spans ultraviolet, visible, and near-infrared wavelengths. This instrument can take a spectrum of many places at once across the center of a galaxy. Each spectrum tells scientists how fast the stars and gas are swirling at that location. With that information, the central mass that the stars are orbiting can be calculated. The faster the stars go, the more massive the central object must be.

STIS found the signature of a super massive black hole in the center of the galaxy M84. The spectra showed a rotation velocity of 400 km/s, equivalent to 1.4 million km every hour! The Earth orbits our Sun at 30 km/s. If Earth moved as fast as 400 km/s our year would be only 27 days long!

Key Points

1. A black hole is an object so compact that, within a certain distance of it, even the speed of light is not fast enough to escape.
2. Elliptical galaxies do not have black holes whereas Spiral galaxies have black holes.
3. A Black Hole is black, has very strong density.
4. A star with a mass greater than 20 times the mass of our Sun may produce a black hole at the end of its life
5. There might be three types of black holes: stellar, super massive, and miniature black holes — depending on their size.
6. A black hole cannot be viewed directly because light cannot escape it.

Self Assessment Exercise 2.6

Q.1 Fill in the blanks.

i. A black hole uses the power of _____to pull things towards it.

a. energy b. gravity
c. hole d. motion

ii. How Stellar black hole is produced?

a. new stars b. older stars
c. dying stars d. big stars.

iii. General theory of relativity was presented by…

a. Armstrong b. Newton
c. Einstein d. Arther Addington

iv. STIS stands for

a. Scientist for technical assistance of space
b. Space Telescope information system
c. Space Telescope Imaging Spectrograph
d. Space technological information system

Q.2 Answer the following questions:

i. What are Black Holes? Why is it important to study it?
ii. Describe the anatomy of the Black Holes?
iii. Do Black Holes emerge from Stars? Discuss.
iv. Discuss the efficiency of Hubble Telescope for searching of black holes?

2.7 The Space

The region beyond the Earth's atmosphere occurring among the solar bodies of the universe. The density of the space is almost negligible, although cosmic rays, meteorites, gas clouds, etc, can occur. The space can be divided into cis-lunar space (between the earth and moon), inter-planetary space, inter-stellar space, and inter-galactic space

2.7.1 Cis - Lunar Space

The region between Earth's atmosphere and the Moon is sometimes referred to as **cis-lunar space**. The Moon passes through geo-space roughly four days each month, during which time the surface is shielded from the solar wind.

Geo-space is mainly composed of electrically charged particles. These charged particles have very low densities and their motion is controlled by earth's magnetic field. Geo-space and ionosphere are disturbed by geomagnetic storms. These storms increase fluxes of energetic electrons that can damage satellite electronics, disrupting telecommunications and GPS technologies.

2.7.2 Inter-planetary Space

Inter-planetary space, the space around the Sun and planets of the Solar System. The volume of interplanetary space is a nearly total vacuum, with a mean free path of about one astronomical unit at the orbital distance of the Earth. However, this space is not completely empty, and is partially filled with cosmic rays, which include ionized atomic nuclei and various subatomic particles. There is also gas, plasma ,dust, small meteors, and several types of organic molecules.

Interplanetary space contains the magnetic field of the Sun. There are also magnetospheres generated by planets such as Jupiter, Saturn, Mercury and the Earth that have their own magnetic fields. These magnetic fields can trap particles from the solar wind and other sources, creating belts of magnetic particles such as the Van Allen Belts. Planets without magnetic fields, such as Mars, have their atmospheres gradually eroded by the solar wind, except mercury.

2.7.3 Inter-stellar Space

Interstellar space is the physical space within a galaxy not occupied by stars or their planetary systems. The average density of matter in this region is about 10^6 particles per cm^3, but this varies from a low of about 10^4–10^5 in regions of sparse matter up to about 10^8–10^{10} in dark nebula. Regions of star formation may reach 10^{12}–10^{14} particles per cm^3. Nearly 70% of this mass consists of alone hydrogen atoms. This also have helium atoms and other trace amounts of heavier atoms formed through stellar nucleo-synthesis. A number of molecules can also form in inter-stellar space like tiny dust particles.

2.7.4 Inter-galactic Space

Inter-galactic space is the physical space between galaxies. The huge spaces between galaxy clusters are called the **voids**. The density of the Universe, is clearly not uniform; it ranges from relatively high density in galaxies (including very high density in structures

within galaxies, such as planets, stars, and black holes) and lower density than the universe's average.

Surrounding and between galaxies, there is plasma that is thought to possess a cosmic rays, and that is slightly denser than the average density in the universe. This material is called the intergalactic medium and is mostly ionized hydrogen; i.e. a plasma consisting of equal numbers of electrons and protons.

Key Points

1. The region beyond the earth's atmosphere occurring among the solar bodies of the universe is called space.
2. The region between the moon and the earth's atmosphere is called cis-lunar Space.
3. The space around the sun and planets of the solar system is called interplanetary space.
4. Physical space within a galaxy not occupied by stars or their planetary system is called inter-stellar space.
5. The physical space between galaxies is called inter- galactic space.

Self Assessment Exercise 2.7

Q.1 Choose the correct answer from the answers given below.

i. The density of space is

a. Higher than air b. Almost negligible
c. Equal to plasma d. Greater than water

ii. The space, _____ is mostly composed of electrically charged particles.

a. Geo-space b. Inter-planetary space.
c. Inte-rstellar space d. The surface of the m

iii. The huge space between Galaxy clusters is called _____.

a. Null b. Voids
c. Nimble d. Clusteral space

Q.2 Answer the following questions:

i. Define space and enlist its different divisions.
ii. Which space is concerned with our Solar System? Discuss.
iii. Describe the type of space whose mass is 70% hydrogen atoms.

Answers to Self Assessment Exercises

Self Assessment Exercise 2.1

Q.1

i.	Star.	ii.	Meteoroid.	iii.	Astronauts.

Q.2 Consult 2.1 to answer this question

Q.3	i.	c	ii.	c	iii.	a

Self Assessment Exercise 2.2

Q.1

i.	Revolve or orbit	ii.	Triton	iii.	84 years
iv.	Jupiter	v.	Iron oxide		

Q.2

i.	a	ii.	D	iii.	a

Q.3 Read section 2.2 to answer these questions.

Self Assessment Exercise 2.3

Q.1

i.	4or 4.5 billion	ii.	Pan Kau	iii.	Nebular.

Q.2 Consult section 2.3 to answer the questions.

Self Assessment Exercise 2.4

Q.1

i.	crust	ii.	24	iii.	Rotation
iv.	Three	v.	30.		

Q.2

i.	b	ii.	b	iii.	d.
iv.	b	v.	b	vi.	d
vii.	b	viii.	d	ix.	b
x.	b	xi.	b	xii.	c
xiii.	c				

Q.3	i.	a	ii.	d	iii.	a

Q.3 Consult section 2.4 to answer the questions.

Self Assessment Exercise 2.5

Q.1

i.	c	ii.	a	iii.	c
iv.	b	v.	c		

Q.2 Consult section 2.5 to answer the questions.

Self Assessment Exercise 2.6

Q.1

i.	b	ii	c	iii.	c
iv.	c				

Q.2 Consult section 2.6 to answer the questions.

Self Assessment Exercise 2.7

Q.1

i.	b	ii.	a	iii.	b

Q.2 Consult section 2.7 to answer the questions.

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