CHAPTER - 1

UNIVERSE

INTRODUCTION

The universe is a huge wide-open space that holds everything from the smallest particle to the biggest galaxy. No one knows just how big the Universe is. Astronomers try to measure it all the time. They use a special instrument called a spectroscope to tell whether an object is moving away from Earth or toward Earth. Based on the information from this instrument, scientists have learned that the universe is still growing outward in every direction. Scientists believe that about 13.7 billion years ago, a powerful explosion called the Big Bang happened. This powerful explosion set the universe into motion and this motion continues today. Scientists are not yet sure if the motion will stop, change direction, or keep going forever.

EVOLUTION OF UNIVERSE

The three main theories put forward to explain the origin and evolution of the universe are:

i. The Big Bang Theory
ii. The Steady State Theory
iii. The Pulsating Theory

(i) The Big Bang Theory: Le Maitre and Gammow proposed this theory. According to this theory, at the beginning of the universe, the whole matter of the universe was once concentrated in an extremely dense and hot (~10^{12}K) fireball. Then about 20 billion years ago a vast explosion (big bang) occurred. The matter was broken into pieces, which were thrown out with high speed in all directions forming stars and galaxies; which are still moving way from one another. According to Hubble's law, the velocity of recession of a galaxy becomes equal to the velocity of light at a distance equal of 20 billing light years. It means, the light rays from stars and galaxies, which are situated at a distance of 20 billion light years or more, can never reach us. Thus this distance becomes the boundary of observable universe. On account of continuous recession, more and more galaxies will go beyond this boundary and they will be lost. As a result of this, the number of galaxies per unit volume will go on decreasing and ultimately a time may come when we may have empty universe.

(ii) Steady State Theory: Bondi, Gold and Fred Hoyle developed this theory. According to this theory, the number of galaxies in the observable universe is constant and new galaxies are continuously being created out of empty space, which fill up the gaps caused by those galaxies, which have crossed the boundary of the observable universe. As a result of it, the overall size of mass of the observable universe remains constant. Thus a steady state of the universe is not disturbed at all.

(iii) Pulsating Theory: According to this theory, the universe is supposed to be expanding and contracting alternately i.e. pulsating. At present, the universe is expanding. According to pulsating theory, it is possible that at a certain time, the expansion of the universe may be stopped by the gravitational pull and they may contract again. After it has been contracted to a certain size, explosion again occurs and the universe will start expanding. The alternate expansion and contraction of the universe give rise to pulsating universe.

GALAXIES

A galaxy contains stars, gas, and dust which are held together as a group by gravity. There may be millions, or even billions, of stars in one galaxy. There are billions of galaxies in the universe.Galaxies are labeled according to their shape. Some galaxies are called "spiral", because they look like giant pinwheels in the sky. The galaxy we live in, the Milky Way, is a spiral galaxy. Some galaxies are called "elliptical", because they look like flat balls. A galaxy may be called "irregular" if it doesn't really have a shape. A new type of galaxy was discovered recently, called a "starburst" galaxy. In this type of galaxy, new stars just seem to 'burst out' very quickly.

(I) The Milky Way

The Milky Way is over 100,000 light-years wide. It is called a spiral galaxy because it has long arms which spin around like a giant pinwheel. Our Sun is a star in one of the arms. When you look up at the night sky, most of the stars you see are in one of the Milky Way arms.

8 Before we had telescopes, people could not see many of the stars very clearly. They blurred together in a white streak across the sky. A myth by the ancient Greeks said this white streak was

a "river of milk". The ancient Romans called it the *Via Galactica*, or "road made of milk". This is how our galaxy became known as the Milky Way.

- A light-year is the distance light travels in one year. It is 9.5 trillion (9,500,000,000,000) kilometers. The size of a galaxy may be as little as a thousand light-years across or as much as a million light-years across.

(II) Quasars

Quasars are farther away from Earth than any other known object in the universe. Because they are so far away from us, it takes billions of years for the light they give off to reach Earth. The light stays the same, it just has to travel a long time to get to us. When we look at a quasar, it is like we are looking back in time. The light we see today is what the quasar looked like billions of years ago. Some scientists think that when they study quasars they are studying the beginning of the universe.

- Quasars give off huge amounts of energy. They can be a trillion times brighter than the Sun! Astronomers think that quasars are located in galaxies which have black holes at their centers. The black holes may provide quasars with their energy. Quasars are so bright that they drown out the light from all other stars in the same galaxy. The word quasar is short for quasi-stellar radio source. Quasars give off radio waves, X-rays, gamma-rays, ultraviolet rays, and visible light. Most of them are larger than our solar system.
- Quasars give off more energy than 100 normal galaxies combined

(III) Dark Matter

- Matter is anything that takes up space and has mass. We are used to matter which we will call visible matter. Visible matter can be seen because it gives off light or reflects light given off by another object. Dark matter cannot be seen. It does not give off light or reflect light.
  Scientists believe that over ninety-percent of the matter in the universe is dark matter. They also believe that by studying dark matter they will gain new information about the universe. Some of the information they hope to discover is the size, shape and future of the universe. Scientists also hope to learn about how galaxies formed by studying dark matter.
- Scientists cannot see dark matter, so they have a special way of studying it. Scientists study dark matter by looking at how it affects visible matter. Scientists use computers and satellites to study dark matter. The Hubble Space Telescope has taken pictures that have helped scientists discover where dark matter can be found.
- Dark matter was once called "missing matter". It was called this because scientists looking at the sky could not find it.

STARS

- A star is a huge, shining ball in space that produces a tremendous amount of light and other forms of energy. The sun is a star, and it supplies Earth with light and heat energy. The stars look like twinkling points of light — except for the sun. The sun looks like a ball because it is much closer to Earth than any other stars. Stars are formed initially from gas and dust. They are composed mainly of the hydrogen gas. Gas are very hot and give off huge amounts of energy in the form of heat and light.Our Sun is a medium sized star. Stars have a life-span of about 10 billion years, after which they will cease to exist.
  Stars are very far away from Earth. The closest Star is about 23.5 trillion miles away.

(I) WHY ARE STARS HOT AND BRIGHT?

Nuclear Fusion and Nucleosynthesis

Stars are giant nuclear reactors. In the center of stars, atoms are taken apart by tremendous atomic collisions that alter the atomic structure and release an enormous amount of energy. This makes stars hot and bright. In most stars, the primary reaction converts hydrogen atoms into helium atoms, releasing an enormous amount of energy. This reaction is called nuclear fusion because it fused the nuclei (center) of atoms together, forming a new nucleus. The process of forming a new nucleus (and element) is nucleosynthesis.

(II) WHAT IS THE CLOSEST STAR?

The closest star to us is the sun! Other than that, the closest star is Proxima Centauri, aka Alpha Centauri C (the dimmest star in the Alpha Centauri system). Proxima Centauri is 4.3 light-years from the Sun.

(III) WHY DO STARS TWINKLE?

The scientific name for the twinkling of stars is stellar scintillation (or astronomical scintillation). Stars twinkle

when we see them from the Earth's surface because we are viewing them through thick layers of turbulent (moving) air in the Earth's atmosphere.

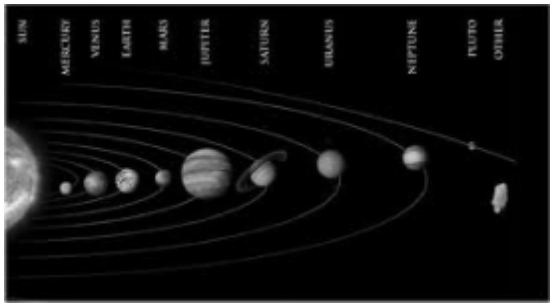
Stars (except for the Sun) appear as tiny dots in the sky; as their light travels through the many layers of the Earth's atmosphere, the light of the star is bent (refracted) many times and in random directions (light is bent when it hits a change in density - like a pocket of cold air or hot air). This random refraction results in the star winking out (it looks as though the star moves a bit, and our eye interprets this as twinkling).

Stars closer to the horizon appear to twinkle more than stars that are overhead - this is because the light of stars near the horizon has to travel through more air than stars overhead and subject to more refraction. Also, planets do not usually twinkle - they are big enough that this effect is not noticeable (except when the air is extremely turbulent).

Stars would not appear to twinkle if we viewed them from outer space (or from a planet/moon that didn't have an atmosphere)

THE SOLAR SYSTEM

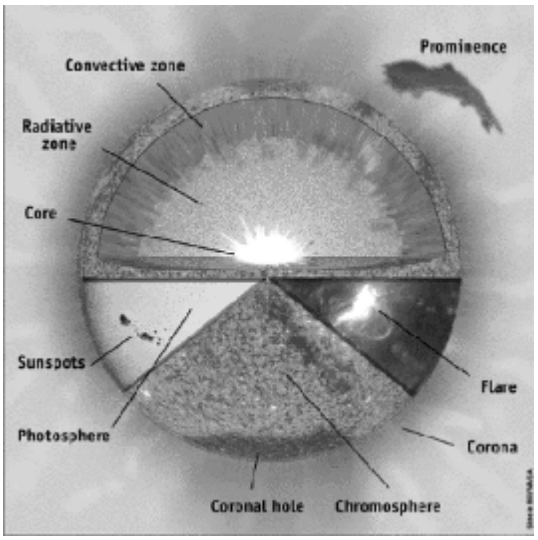
The word "**solar**" refers to the sun; the sun is one of the 150 billion stars of the Milky Way. It moves through space taking with it a larger family of objects. The whole group is called the **solar system**. Our solar system is elliptical in shape. The sun is the center of the solar system. Solar system is always in motion. Its largest and most important members are the nine known planets and their moons, along with smaller objects called comets, asteroids, and meteoroids that orbit the sun. The sun is the biggest object in our solar system. It contains **99.8%** of the solar system's mass. Many scientists believe that our Solar System is over **4.6 billion** years old.



8 Scientists believe that the solar system was formed when a cloud of gas and dust in space was disturbed, may be by the explosion of a nearby star called **SUPERNOVA**. This explosion made waves in space that squeezed the cloud of gas and dust. Squeezing made the cloud start to collapse, as gravity pulled the gas and dust together, forming a **solar nebula**. The sun's nuclear fires, ignited at the dense center of this nebula. The planets were born in the swirling currents of the great cloud.

8 The planets Mercury, Venus, Earth, and Mars, evolved as globes of rock that are present near the Sun. They were too small and their gravitational fields too weak to capture. However, far from the sun, the massive planets Jupiter and Saturn, with powerful gravitational fields, did attract and hold thick gaseous atmospheres of Hydrogen and Helium.

THE SUN



The Sun is our closest star. It is a member of the **Milky Way galaxy**. The diameter of the Sun is **1,392,000 kilometers**. It is believed to be over **4 billion** years old. The Sun is a medium sized star known as a **yellow dwarf**. The Sun spins slowly on its axis as it revolves around the galaxy. The Sun is a large ball of gas consisting mostly of hydrogen and helium. The Sun is about 109 times larger than Earth.

The center, or core, of the Sun is very hot. The temperature in its core is estimated to be over **15,000,000 degrees Celsius**. A process called "**nuclear fusion**" takes place there. Nuclear fusion produces a lot of energy. Some of this energy travels out into space as heat and light. Some of it reaches the Earth! We can see storms on the Sun's surface called as "**sunspots**" because they look like dark spots on the Sun's surface. The Sun also produces big explosions of energy called solar flares. These flares shoot fast moving particles off the Sun's surface. These particles can hit the Earth's atmosphere and cause a glow called an Aurora.

- **The Sun has several layers:** the core, the radiation zone, the convection zone, and the photosphere (which is the surface of the Sun). In addition, there are two layers of gas above the photosphere called the chromosphere and the corona. The following are the events that occur on the Sun frequently: sunspots, solar flares, solar wind, and solar prominences.
- Without the Sun, the Earth would be a lifeless ball of rock and ice. The Sun warms our planet, creates our weather, and gives energy to plants providing food and energy to support life on Earth. The Sun is a large ball of gas consisting mostly of hydrogen and helium. The Sun is about 109 times larger than the Earth. Scientists estimate that the temperature at the center of the Sun is about 15 million degrees Celsius. This is similar to exploding a hydrogen, or nuclear, bomb. Large explosions on the Sun's surface cause solar flares that shoot up high into space. The surface temperature is about **4000 degrees Celsius**. Energy released from the Sun radiates in all directions, reaching the Earth and other planets. The further the planet is from the Sun, the less energy it receives.

Other Objects in the Solar System

Asteroids: Asteroids are rocky and metallic objects that orbit the Sun but are too small to be considered as planets. They are known as minor planets. Most of the asteroids in our solar system can be found orbiting the Sun between the orbits of Mars and Jupiter. This area is sometimes called the "asteroid belt". A few asteroids approach the Sun more closely.

Asteroid belt: The asteroid belt is a doughnut shaped concentration of asteroids orbiting the Sun between the orbits of Mars and Jupiter, closer to the orbit of Mars.

Comets: A comet is made of dirty ice, dust, and gas. Scientists believe that comets are made up of material left over when the Sun and the planets were formed. When a comet gets close to the Sun, part of the ice starts to melt. Scientists think about 100,000 million comets orbit the Sun. There are some comets orbiting the Sun like planets. Their orbits take them very close to and very far away from the Sun.Comet can be seen only when it comes close to the Sun. The Sun's heat melts the comet's ice to form glowing gases. The gases stream out into a long tail that can extend to millions of kilometers.

Meteorites: Besides asteroids some smaller pieces of rocks and dust also orbit the Sun. These pieces of rock or dust enter the Earth's atmosphere. As they pass they encounter great friction, which causes them to heat up and burn out. These burning pieces of rock or dust are called as **meteors.** Although they are not stars, people call them as shooting stars, because they flash light across the sky. Most of the meteors burn up before they reach the Earth. Some are so large that a part of it reaches the ground as a meteorite.

Any leftover part that does strike the Earth is called a **meteorite**. A meteorite can make a hole or crater in the ground when it hits it. The larger the meteorite, the bigger the hole.

Sun Reference Data

Diameter:	1.4 million km (870,000 miles)	**Age:**	4.5 billion years
Mass: (93 million miles)	330,000 x Earth	**Distance from Earth:**	149.6 million km
Density:	1.41 (water=1)	**Distance to Nearest Star:**	4.3 light years
Solar Wind	3 million km/hr.	**Luminosity:**	390 billion billion megawatts
Speed:			
Solar Cycle:	8 - 11 years	**Temperature**	5,500° C (9,932° F)
atsurface:			
Temperature	14 million° C	**Temperature of**	4,000° C (7,232° F)
at Core:		(22.5 million° F)	**Sunspots:**
Rotation Period	25 Earth days	**Rotation Period**	35 Earth days
at Equator:		**at Poles:**	

PLANETS

By the current count of astronomers, our solar system includes 8 planets and 5 dwarf planets. The planets were formed during the process of solar system formation, when clumps began to form in the disk of gas and dusk rotating about our young Sun. Eventually, only the planets and other small bodies in the solar system remained. The four rocky

planets at the center of the solar system Mercury, Venus, Earth, Mars, are known as the inner planets. Jupiter, Saturn, Uranus, and Neptune are all composed primarily of gas and are known as the outer planets.

i. Mercury

Mercury, the planet nearest the Sun, is also the smallest planet in the Solar System. Only slightly larger than the Earth's moon, Mercury's surface is covered with craters. This tiny planet does not have any rings or moons.

ii. Venus

Fair but inhospitable Venus, a "Sister" planet to the Earth that is very different from our home. Venus does not have any moons or rings.

iii. Earth

Earth, our home planet, is a beautiful blue and white ball when seen from space. The third planet from the Sun, it is the largest of the inner planets. Earth is the only planet known to support life and to have liquid water at the surface. Earth has a substantial atmosphere and magnetic field, both of which are critical for sustaining life on Earth. Earth is the innermost planet in the solar system with a natural satellite – our Moon.

iv. Mars

Mars, Earth's outer neighbor, is the fourth planet from the Sun. Mars' bright appearance and reddish color stand out in the night sky. Impressive surface features such as enormous volcanoes and valleys are frequently obscured by huge dust storms.

v. Jupiter

Jupiter is the largest planet in the solar system. When approached from afar, its fantastic striped atmosphere gradually reveals intriguing clouds that move around the planet. Rich in historical and cultural connections, Jupiter is the site of recent comet impacts and continuing scientific discovery.

vi. Saturn

Saturn, the sixth planet from the Sun, has the most spectacular set of rings in the solar system. We now know that Saturn has 62 moons in addition to its complex ring system.

vii. Uranus

Uranus, the seventh planet from the Sun, has its spin axis almost in the plane of its orbit about the Sun. This produces unusual seasons and also causes unique magnetic and electric field structures. Uranus has a faint ring system and 27 known moons.

viii. Neptune

Neptune, the eighth and furthest planet from the Sun, is a very cold place. Its bluish color is caused by small amounts of methane gas in its atmosphere. The planet has 13 moons and a very narrow, faint ring system.

DWARF PLANETS

In 2006 the International Astronomical Union (IAU) approved a new classification scheme for planets and smaller objects in our Solar System. Their scheme includes three classes of objects: "small solar system bodies" (including most asteroids and comets), the much larger planets (including Earth, Jupiter, and so on), and the new category of in-between sized "dwar+f planets".

There are currently five official dwarf planets. Pluto, formerly the smallest of the nine "traditional" planets, was demoted to dwarf planet status. Ceres, the largest asteroid in the main asteroid belt between Mars and Jupiter, was also declared a dwarf planet. The three other (for now!) dwarf planets are Eris, Makemake, and Haumea. Pluto, Makemake, and Haumea orbit the Sun on the frozen fringes of our Solar System in the Kuiper Belt. Eris, also a Trans-Neptunian Object, is even further from the Sun.

What's the difference between regular planets and dwarf planets?

It's partly an issue of size, with dwarf planets being smaller. But just how big does a planet need to be to become a full-fledged planet instead of a dwarf? You might think the minimum size requirement is arbitrary, but the size cutoff is actually based on other properties of the object and its history in the Solar System. Both planets and dwarf planets orbit the Sun, **not** other planets (in which case we call them moons). Both must be large enough that their own gravity pulls them into the shapes of spheres; this rules out numerous smaller bodies like most asteroids, many of which have irregular shapes. Planets clear smaller objects out of their orbits by sucking the small bodies into themselves or flinging them out of orbit. Dwarf planets, with their weaker gravities, are **unable** to clear out their orbits.

Though there are just five dwarf planets now, their number is expected to grow. Scientists estimate there may be 70 dwarf planets amongst outer solar system objects that have been discovered already. Since we don't know the actual sizes or shapes of many of the objects we've found (because they are so far away), we can't yet determine whether they are actually dwarf planets or not. More observations and better telescopes will help us determine which other objects are dwarf planets.

EARTH

The **Earth** is the third planet from the Sun in our Solar System. It is the planet, we evolved on and the only planet in our Solar System that is known to support life. It is **149.6 million kilometers** away from the Sun. It has one moon. The Earth is the fifth-largest planet in our Solar System (after Jupiter, Saturn, Uranus, and Neptune).

- The Earth's atmosphere is ideal for supporting life. Most of the Earth's surface is covered with water. From the sky, the Earth appears blue. Earth is the only inner planet in our solar system that has liquid water on its surface. Seventy percent of the Earth's surface is covered with water. Mountains, volcanoes, deserts, plains, and valleys cover the remaining 30 percent. Earth has an atmosphere made up of many different gases. The atmosphere gives us air to breathe. We live on the planet Earth.
- Each day on the Earth takes **23.93 hours** (that is, it takes the Earth 23.93 hours to rotate around its axis once). Each year on the Earth takes **365.26 Earth days** (that is, it takes the Earth 365.26 days to orbit the Sun once).

(I) Rotation and Revolution of the Earth

(a) Rotation of the Earth: The Earth orbits around the Sun. It takes one year to go around the Sun one complete time. The Earth also rotates, or spins, on its axis. It takes one day to spin around itself one complete time. The Earth's axis is not straight up and down, but tilted at an angle of 23.5 degrees. The rotation is what causes the change from day to night. This tilt is responsible for having seasons. If the Earth were not tilted, we would have the same season all year long.

(b) Revolution of the Earth: The movement of the Earth around the Sun in a fixed orbit is called as revolving. One full orbit around the sun is one revolution. The Earth takes 365 days or 1 year to complete one revolution. The Earth revolves around the Sun because of gravity. The Earth really rotates 365 ¼ times during each revolution. The calendar always has 365 days, after every 4 years, the earth has made one extra rotation. How ever, one extra day is added to the month of February once in every four years forming a leap year with 366 days.

(II) Day and Night

The Earth exhibits two different kinds of motion. One is rotation around its own axis and another movement is it revolves around the sun in a fixed orbit. The spinning of the Earth around its own axis causes day and night. It takes 24 hours to complete one rotation. However, sunlight shines only on the half of the Earth facing the Sun. That half has day the other half is dark and has a night.

THE MOON

The moon is a satellite that revolves around the Earth in an oval shaped orbit. Earth's moon is smaller than the Earth. It is smaller than the sun. It looks bigger because it is much closer to the Earth. It is 240,000 miles (384,000 kilometers) away.

Moon appears in the nighttime. The Moon turns so slowly that a moon's day is two Earth-weeks long. Then it is night for the next two weeks. The moon is very hot during daytime and gets very cold at night. It appears hotter than boiling water because there is no air to protect the moon from the hot sunlight. It gets very, very cold during night because there is no air to hold heat on the moon. The moon has no atmosphere, air or water, to support life. Moon can be seen clearly with your eyes, binoculars, or a telescope.

Many manned and unmanned spacecrafts from the United States and Russia, Japan, China, India, have landed on the moon to study its surface. The surface of the moon has many craters caused by being hit by large meteoroids and asteroids. The moon is much like Earth in some ways. Its rocks are similar to Earth rocks. Lava rock from underground volcanic eruptions look like the lava rocks found on Earth.

(i) Rotation of the Moon
(ii) The Moon takes 29 1/3 days to make one orbit around the Earth. It also takes 29 1/3 days to complete one rotation on its axis.
(iii) The phases, or changing appearance, of the Moon depends on its position in relation to the position of the Sun.
(iv) Atmosphere of the Moon

The moon is much like the Earth in some ways. Its rocks are similar to Earth rocks. The moon has no atmosphere, air or water, to support life. There are tall mountains and flat, dusty plains on the moon. The big holes on the moon are called Craters, which are made when space rocks hit the moon.

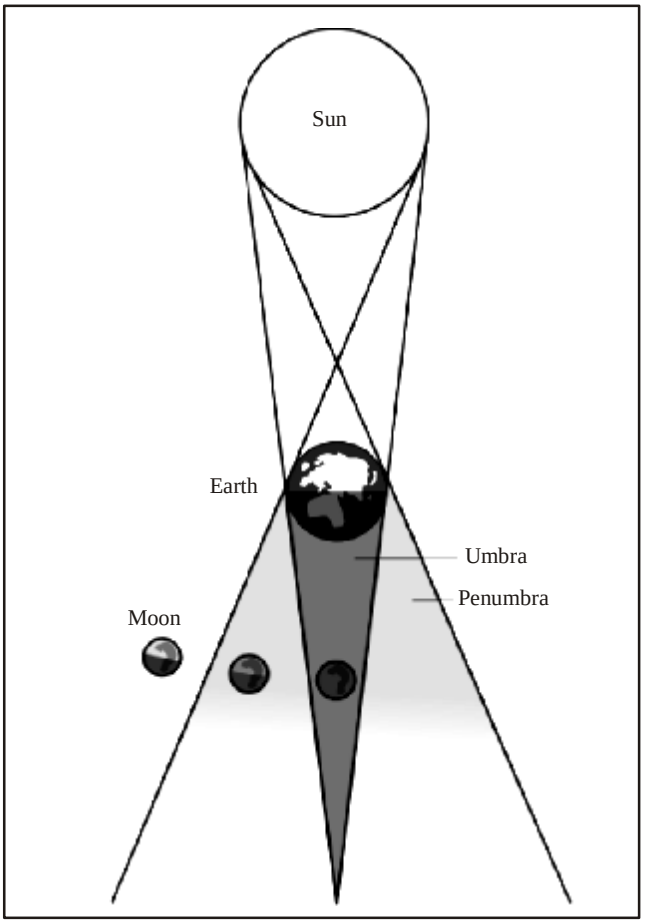
(a) Light from the Moon

We always see the one side of the Moon from the Earth. You have to go into space to see the other side. Moon does not make its own light. We can see it because it reflects light from the sun.

(b) Eclipse of the Moon

Every object, the Sun shines on casts its shadow. The Earth and moon also cast their shadows on each other. Most of the times these shadows fall on empty space. But sometimes we can see them from the Earth. As the moon revolves around the Earth, at times the Sun, the Earth, and the Moon are in a straight line.

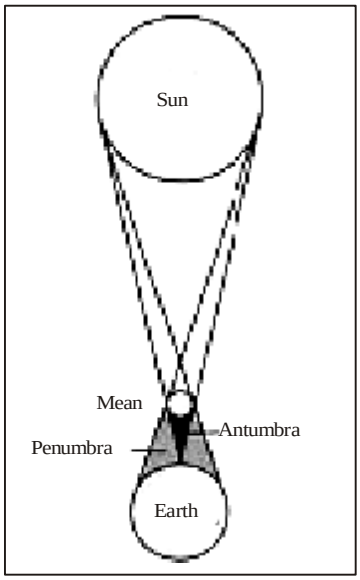
LUNAR ECLIPSE



The Earth blocks the sun's light falling on the Moon. The Moon appears to be dark for a brief period, after which you would see a full moon. This is called as "**Lunar Eclipse**". It occurs when the shadow of the Earth falls on the Moon. It occurs only on a full moon day, but not on all full moon days.

SOLAR ECLIPSE

When the moon casts its shadow on the Earth it is called as "**Solar Eclipse**". It occurs only on a new moon day, but not on all new moon days.



SEASONS

You might have observed that the seasons change as a year progresses. You might have felt the heat of the summer and the chill in the winter. What causes these seasonal changes?

The Earth takes about one year to revolve around the Sun, and also it rotates on its axis. The axis on which the Earth rotates is slightly tilted, and this causes the cycle of seasons. While the Earth is revolving, if the Northern Hemisphere gets the direct sunlight, it has summer and on the other side, the Southern Hemisphere, will have winter. When the Southern Hemisphere faces direct sunlight it will have summer and it will be winter in the Northern Hemisphere.