Why do elliptical galaxies contain fewer blue stars than spiral galaxies?

Can you see a black hole? How does a black hole look like?

What invention prompted scientists to think about entering space to explore it?

12

Our Universe

Students' Learning Outcomes

After studying this chapter, students will be able to:

- Explore and understand the terms star, galaxy, Milky Way and the black holes.
- Compare the types of galaxies.
- Relate the life of a star with the formation of black hole, neutron star, Pulsar White Dwarf, Red Giant.
- Discuss the birth and eventual death of our Sun.
- Show how information is collected from space by using telescopes (e.g., Hubble Space Telescope) and space probes (e.g., Galileo.
- Describe advancements in space technology and analyze the benefits generated by the technology of space exploration.

Our universe comprises billions of heavenly objects in a vast empty space. There are galaxies, stars, planets, comets and many other mysterious objects. When we look up the night sky, we see numerous twinkling stars. A star is actually a gigantic ball of burning gases which emit heat and light. Most of the stars are so far away from the Earth that their light reaches us in years. Scientists believe that the universe is still expanding. Our Sun is the nearest star that is 15 millions kilometres away from the Earth.

12.1 GALAXIES

The word galaxy comes from the Greek word "gala" meaning "milk". Our galaxy looks like a milky cloud in the night sky. Hence, it is popularly known as Milky Way Galaxy. Its top as well as side view is shown in Fig.12.1. It is spiral type galaxy with mostly old stars at its centresurrounded by a halo of newly generated stars. The estimation is that there are more than a billion stars in this galaxy. This galaxy circles the whole sky. Our Sun along with its solar system is situated in one of its spiral arms. The stars which we see during the night are

all parts of the Milky Way Galaxy. There is still enough gas and other matter in its arms for many moregeneration of stars.

(a) Top view

(b) Side view

Figure 12.1 Spiral galaxy

Interesting information

Astronomy is a very old science. Overtimes, it was about the study of objects seen in the night sky. Now it is the study of the whole universe which includes many mysterious and unseen objects.

Do you know?

Stars are large distances apart. A new unit of distance has been defined known as a light year. It is the distance that light travels in one year. This distance is 9.5 trillion kilometres.

Do you know?

The astronomers through radio-telescope collect information about astronomical objects.

Interesting Information

Milky Way Galaxy

Age	13.6 billion years
Diameter	106,000 light years
Thickness of the centre	10,000 -15,000 light years
Speed in space	2,100,000 kilometre per hour
Revolving Speed	Once cycle in 225,000,000 years
Approximate distance of the Sun from the centre of the galaxy	21,000 light years

Andromeda is our neighbouring galaxy which we can see without a telescope during the clear night. It is bigger than our galaxy and situated about 2.5 million light years away form us.

12.1.1 Types of Galaxies

There are many types of galaxies. Some major types are given below:

Figure 12.2

1. Spiral galaxies

A galaxy that has a flat disklike shape with a bulge in the middle is called Spiral Galaxy. It rotates about its centre. Milky Way and Andromeda galaxies are spiral galaxies.

2. Elliptical galaxies

They look like flattened balls. They are oval shaped. They contain mostly old stars and do not rotate around their centres. They are most abundant type of galaxies in the universe. They are dim and old.

3. Jelly fish galaxies

Another amazing type is like a Jelly fish swimming across a sea of stars known as Jelly Fish Galaxy. They have giant tails looking as blue ribbons of young stars extended away from the galaxy disk. More than 30 such galaxies have been discovered.

4. Irregular galaxies

They do not have any district regular shape. They are mostly small galaxies of different shapes. They are most unusual galaxies.

12.1.2 Stars

A typical star consists of hydrogen gas. Huge gravitational forces squeeze the atoms together to form helium along with the release of tremendous amount of energy. The energy is radiated into space as heat and light. Stars can be classified by their size, mass, brightness, colour, temperature and age. There are yellow stars, red giants, blue giants, super giants, and white dwarfs. Our Sun is a yellow star of medium size and is often called a dwarf star. Its surface temperature is 6,000°C but at its centre it is 15 million degrees centigrade. It is shining for the last 5 billion years and is expected to shine still for another 5 billion years before it dies. After the Sun, the nearest star is Proxima Centauri located more than four light years away.

Figure 12.3

Hubble Space Telescope

This telescope is orbiting the Earth at a height of about 500 km. It has relayed detailed images of distant stars and galaxies. You can enjoy the fascinating images sent by Hubble Telescope on the Internet and share with the classmates.

For your information:

NASA has announced recently the observation of a rare event, the merger of three galaxies about 618 million light years away.

Interesting information

What the Earth would be like if there was no Sun and what would be its impact on the environment?

12.1.3 Birth and Death of a Star

Stars also undergo a life cycle. During the first stage, the gravity pulls the clouds of gas and dust resulting in a hot spinning ball. It is known as a protostar not giving light. In a process that takes million years, its further shrinkage causes huge build up of pressure and heat. At a temperature around 10 million degrees centigrade, the hydrogen starts changing into helium releasing enormous heat and light and a star is born.

During its second stage extending billion years, the shining star usually uses up its hydrogen fuel slowly. In the third stage when its fuel is depleted, the star expands and cools to form a red giant or super giant giving more red light for another million year. In the fourth stage, red giant will cool and gravity will squeeze further to form a white dwarf (Figure12.4.) It is a small hot dim star that is the leftover centre of a dying star. White dwarf slowly fades away over million years to form black dwarf. It will not emit light. Its material returns to space.

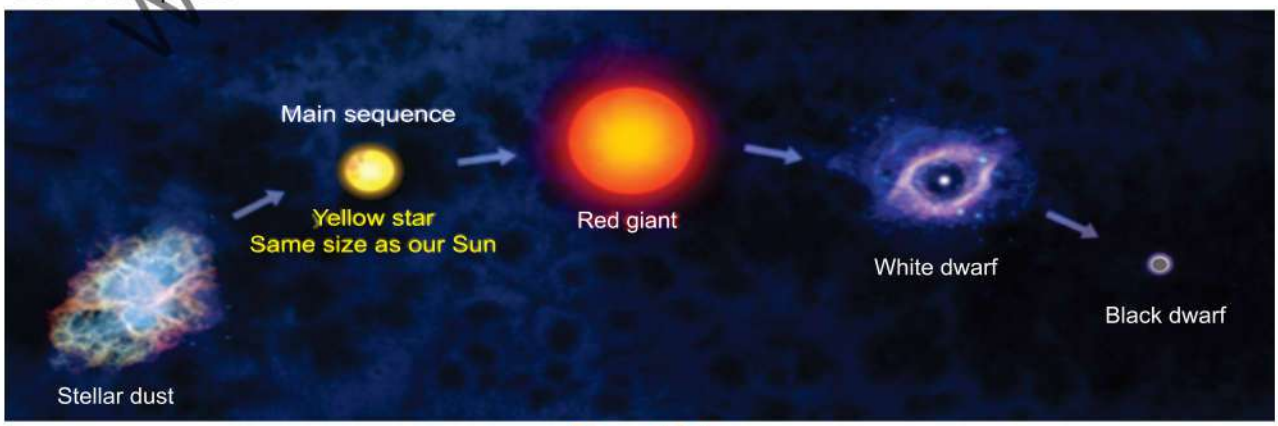

Figure 12.4

Activity 12.1

The teacher will arrange a 'play' or a class discussion about what will happen if they woke up one day and found out that the Sun has died.

12.1.4 Neutron Stars and Pulsars

The stars three or more times bigger than the Sun are called massive stars. Massive stars burn their fuel much faster. After only 50 million years, their hydrogen gas is exhausted. They become red super giants and their size increases. Sometimes the core of super giants suddenly collapses creating a huge explosion and much more light is emitted. If mass of the core is more than one and half to three times than the mass of the Sun, the left over core of the star entirely consisted of neutrons and is called neutron star (Figure 12.5). Neutron stars are extremely dense objects

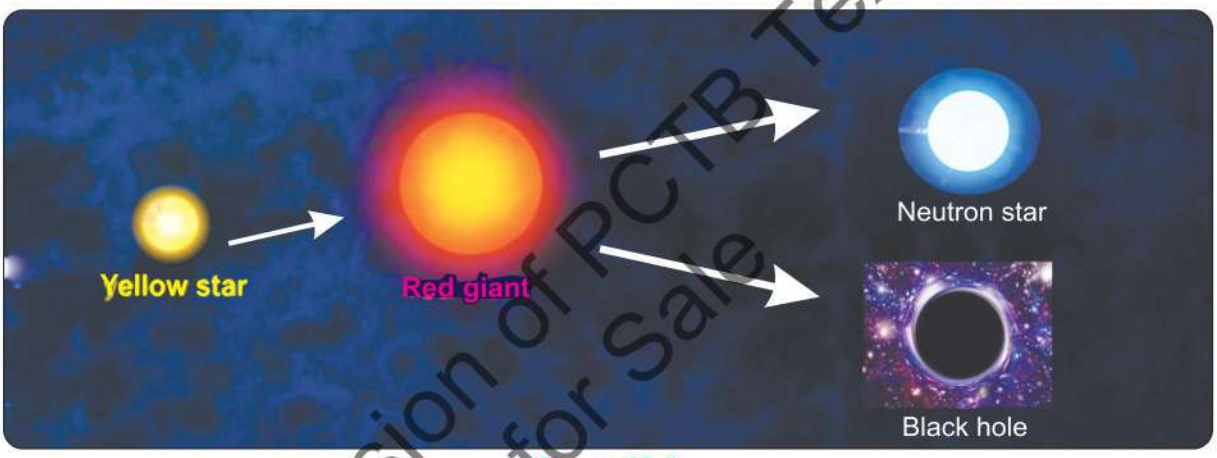

Figure 12.5

Do you know?

The William Hersched Telescope in the Canary Island (USA) is one of the biggest optical telescope. It can detect a single burning candle from a distance of 160,000 km away.

Neutron stars emit higher energy radiation such as X-rays. If a neutron star is spinning, it is called pulsar (Figure 12.6). It sends out radiation beam all around and is detected by radio-telescopes as rapid clicks and pulses.

Figure 12.6

Interesting information

Neutron stars are extremely dense stars usually of diameter 10 km to 16 km but their mass can be equal to the mass of our Sun.

12.1.5 Black Holes

Black Hole is an object so massive and dense that even light cannot escape from its pull. The chances of black hole formation are more when the mass of the core of the collapsing star is greater than three times the mass of the Sun. Due to intense gravity, the core of the star is crushed to such a small size that nothing, not even light escape and hence it cannot be seen. It is detected indirectly by the gravity waves. Another evidence of its existence is the stream of X-rays bursted away when it swallows nearby stars. It is believed that there is a black hole somewhere near the center of our Milky Way Galaxy.

12.1.6 Evidence that Black Holes Exist

Black Hole is an invisible object. Their existence can be verified by some effects caused by them:

i. It has been observed by tracking the stars near the center of Milky Way Galaxy orbiting a massive invisible object most likely a black hole about two million times the mass of the Sun.

ii. When the core of the massive star collapses, quick release of energy in the form of X-rays burst takes place which can be detected by radio-telescope. In fact, the radio-telescope on the Earth has detected many such events.

iii. When a star collapses to form a black hole or when two black holes collide, the violent event sends gravitational waves rippling out through space. It was a great triumph for the mankind when on 14th September, 2015, scientists of a special lab popularly known a LIGO detected a violent disturbance in space caused by gravitational waves generated by two colliding black holes 1.3 billion light years away from the Earth (Figure 12.7).

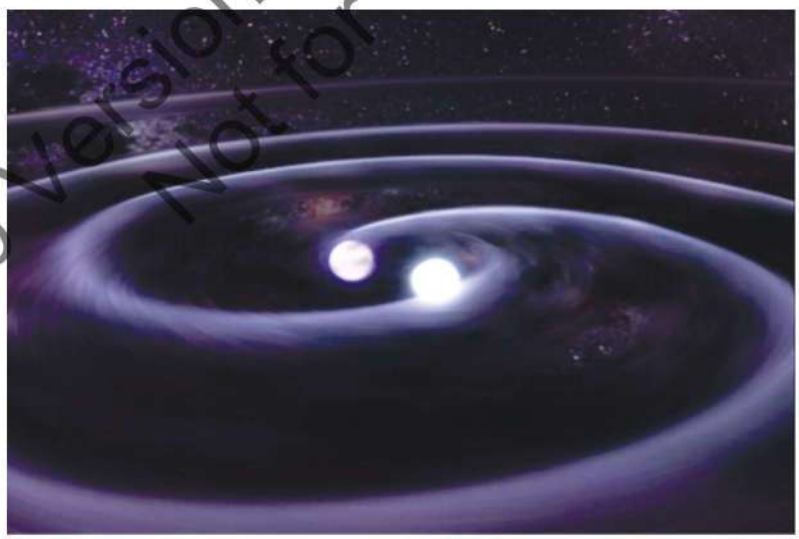

Figure 12.7

Interesting information

It is predicted that mostly the large galaxies do have one or more black holes near their centres.

Evolution of Telescope

1. Galileo 1609

2. Hubble 1990

3. James Webb 2021

James Webb Telescope: It is a space telescope launched on 25th December, 2021 to orbit the Sun at a distance of around 1.6 million kilometres as compared to Hubble which orbits the Earth at a height of about 500 km. It is expected to explore undiscovered mysteries from far off places of our universe by sending marvalous images even including neutron stars and possibly of black holes.

12.2 SPACE EXPLORATION

Scientific study of the space using especially developed technology is called space exploration. Common objectives for exploring space include advancing scientific knowledge, ensuring the future survival of humanity and developing defense capabilities.

Benefits of Space Exploration

Special technologies developed for space are now being used on Earth to improve the quality of life. A few examples are as follows:

1. Improving health care

In the field of health and medicine, space exploration has enabled man to develop medical diagnostic devices and treatment processes. Devices are used for getting instant relief in muscles, joint pains and arthritis (Figure 12.8).

- The infrared thermometer has been developed to measure the temperature of body without contact (Figure 12.9).
- Kidney dialysis machines and mini cameras for taking the photographs of internal organs of human body have been developed using the research output of space exploration.
- The materials used to keep our homes warm are based on the technology used for insulating the space stations.

Figure 12.8 High intensity LED unit

Figure 12.9 Infrared ear thermometer

2. Global navigation

1. Geostationary Orbits and Global Positioning System (GPS) use the network of satellites orbiting the Earth to facilitate communication and essential navigation (Figure 12.10). This system helps our television receivers and mobile phones to receive signals from the satellites moving around the globe.
2. The travellers can use this system not only for knowing where they are travelling but also for selecting best route to their destination. Aeroplane pilots, sailors of the ships or desert hikers also use the GPS in mobile phones to find their positions and get information about the surroundings.
3. Ride Hailing companies such as Uber/Careem use space navigation services to manage quick location and calculate distances.
4. Help tracking of packages and their efficient delivery by courier services.

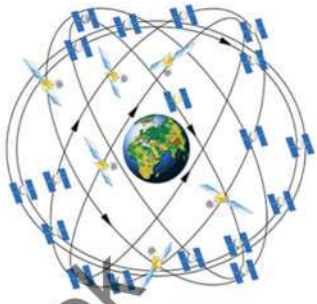

Figure 12.10
GPS satellites orbiting around the Earth

3. Weather forecast and prediction of natural calamities

- The accurate and reliable weather reports on hourly basis are possible because of the weather satellites in the space (Figure 12.11). These satellites have also made it easy to predict natural calamities such as floods, storms, tornadoes and hurricanes.

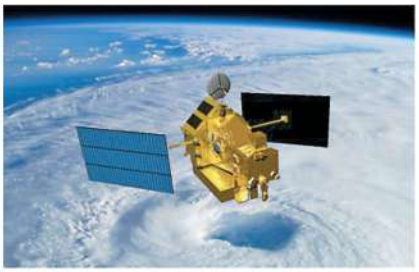

Figure 12.11: Weather satellite

4. Advanced electronics and computers

- Electronic and computer systems were developed mainly to facilitate space exploration. Satellites are fitted with electronic and computer systems which can perform many functions automatically. Now-a-days many items are made in factories automatically or by computer-controlled robots.

5. Locating minerals, fossil fuels and water reserves

1. Deeply buried precious ores of minerals, fossil fuels (coal, petroleum and natural gas) and underground water reserves can be located with the help of satellites (Figure 12.12). This study is known as remote sensing.
2. Protecting our environment and climate monitoring.
3. Aerial mapping of Earth surface provides data on climate change, measure pollution and scanning for greenhouse gases help to plan for the overall health of the planet and fixing climate change problems.
4. Adopting spacecraft technologies, the cabin pressure maintaining system are allowing people to travel comfortably in commercial airplanes

Figure: 12.12
Locating ores and resources

12.3 HOW DO ASTRONAUTS SURVIVE AND RESEARCH IN SPACE?

For living in space, astronauts need basic necessities (air, food, water, shelter and warmth) for survival, and a suitable compartment for personal comfort on the spacecraft. For this purpose, large space stations have been built in the space. Each space station consists of two main sections: (i) Pressurized section in which scientists work without space suits. (ii) Open-to-Space section on which equipment is mounted for observing the Earth and sky. Unprotected human body cannot survive more than a few minutes in space. As liquid boils at lower temperature and lower pressure, the water in human body can begin to boil at low pressure resulting immediate death. The astronauts wear a specially designed suit called space suit to protect from such hazards when they go out into space (Figure 12.13). For breathing in space, astronauts carry air tanks with them that contain pressurized oxygen and nitrogen. Their suits circulate the air to their helmets and throughout the suit so that they can breathe. Special foods are prepared and packed for easier transportation and a variety of tastes for the astronauts.

Figure 12.13
Astronaut wearing space suit

For your information

An astronaut is a scientist who is trained to travel in space.

12.4 TECHNOLOGICAL TOOLS USED IN SPACE EXPLORATION

A few of the tools which are used in space exploration programmes are as follows:

1. Space Rockets

Space rockets are the means of transporting spacecrafts, space shuttles and space stations into the space (Figure 12.14).

Figure 12.14 Space rocket

2. International Space Station (ISS)

It is habitable artificial satellite built with the collaborations of 18 countries including USA, Russia, Japan, Europe and Canada. The station serves as a gravity free and space environment research lab. Scientists from all over the world visit this space station and many of them stay in it for several months. Space shuttles are used to and back transportation of scientists and other goods. The ISS is an example that humanity can do when we agree to work together towards a single goal of human welfare, progress and prosperity.

2. Rocket Launching Pads

The sites from which rockets are launched into space are called Rocket Launching Pads (Figure 12.15). These are especially built platforms for firing rockets into the space. They can withstand extremely high temperature and large forces produced by rocket exhausts.

Figure 12.15 Rocket launching pad

4. Telecommunication System

Rockets and spacecrafts are provided with telecommunication system so that the space crew in the rocket capsule can communicate with each other and with the Earth stations.

5. Ground Mission Control Stations

Ground stations receive and process the information from satellites to monitor and guide their motion in space. The main tasks of ground mission control are as follows:

i. Tracking

Continuously reporting the position of the satellite or space probe.

ii. Monitoring

Receiving signals from a spacecraft and decoding them into useful information for the scientists is known as monitoring. Progress of a space mission is closely observed and necessary instructions are issued from time to time.

6. Space Probes

They are the spacecraft which are exploring space for more than fifty years. One of the spacecraft named Galileo was launched in October,1989 on Jupiter mission. It started orbiting around of Jupiter in December, 1995. It revealed many thunderstorms on Jupiter, larger than on Earth's surface. Voyager-1 and 2 launched in 1971 and Pioneers-10 and 11 are travelling through space with a speed of 40,000 km per hour.

They have visited all the planets of solar system as well as two dwarf planets Pluto and Ceres. They have sent many close up pictures of the heavenly objects. They have helped to discover more than 2400 comets. They are still transmitting data from far beyond the solar system.

Do you know?

In 1990, the spacecraft Voyager-1 captured view of our Earth as a pale blue dot from a distance of 6 billion kilometres away.

For your information

Achievements of LIGO

As of January 2022, the LIGO lab has undergone 3 search runs. First run was from 12th September to 19th January, 2016 in which three events were detected, all of black hole mergers in distant galaxies. In second run, from 30th November, 2016 to 25th August, 2017, 8 detections observed, 7 black hole mergers and first neutron star. In third run, from 01st April 2019 to 27th March, 2020, the first merger of neutron star with a black hole was observed.

12.5 NEW TECHNOLOGIES DEVELOPED ON THE EARTH AS A RESULT OF SPACE EXPLORATION

We have learnt in Section 12.2 about the technologies and benefits of space exploration. Some of the new technologies developed on the Earth as a result of space exploration are listed below:

1. Special types of metal alloys and ceramic materials developed for rocket engines and space shuttles can withstand very high temperature and pressure. These are now being used in Jet engines. Similarly, special foam seats developed for spacecrafts are now being used in aeroplane and car seats.
2. Solar cells were originally developed to provide electricity to spacecrafts. Millions of them are being installed on the Earth now-a-days to produce almost free electricity from sunlight.
3. Special Glues, adhesives, epoxies, aerogels, etc. were originally invented for space engineering but are now widely used in everyday life.
4. Advance robotics, automation and artificial intelligence needed by space exploration now have revolutionized the industrial production and many other processes. More space exploration promises to bring benefits to a variety of areas such as power generation, power transmission, and tackling many other threats to mankind.

Point to Ponder

What would happen to astronauts' blood if their suit or the space shuttle were not airtight?

KEY POINTS

- Star distances are measured in light years. A light year is a distance that light travels in one year.
- A star like Sun starts its life as a protostar. Then it changes to a star emitting light and heat.
- When the nuclear fuel of the star is spent, a star like Sun expands to become a red giant. Then collapses into a white dwarf.

KEY POINTS

- A black hole is the last stage in the life of a massive star. A black hole is so dense that not even light can escape form it.
- Global Positioning System (GPS) helps a television receiver, or a mobile phone to catch signals from the satellites moving around the globe for navigation and communication.
- Knowledge gained from space exploration has enabled man to develop technologies to serve the mankind in different fields like health and medicine, navigation, weather forecasting, locating minerals, fossil fuels and water reserves.
- Space rockets, rocket launching pads, telecommunication system, telescopes, spectroscopes, etc. are different technological tools used in space exploration.
- The application of space exploration technologies has improved business, industry and quality of life on the Earth.

QUESTIONS

1. Encircle the correct option.

(i) An instrument that helps in seeing heavenly objects:

(a) microscope (b) telescope
(c) periscope (d) kaleidoscope

(ii) Telescope on the Earth suffers from the defect that light coming from the stars has to pass through:

(a) space (b) water
(c) atmosphere (d) clouds

(iii) A vehicle designed to carry an artificial satellite in outer space is:

(a) rocket (b) airbus
(c) jet Plane (d) spacecraft

(iv) Star's distances are measured in:

(a) kilometres (b) nauticalmiles
(c) light years (d) miles

(v) The colour of hottest star is:

(a) red (b) blue
(c) yellow (d) white

(vi) Our Solar system is a part of:

(a) andromeda galaxy (b) milky way galaxy
(c) jelly fish galaxy (d) irregular shaped galaxy

(vii) Surface temperature of the Sun is:

(a) 3000 °C (b) 6000 °C (c) 15000 °C (d) 1,500,000 °C

(viii) The last stage in the life of massive star is:

(a) red giant (b) white dwarf
(c) super giant (d) black hole

(ix) Bright stars may appear dim stars because they are:

(a) old star (b) new Star
(c) far away from Earth (d) close to the Earth

(x) The nearest star after the Sun is:

(a) rigel (b) proxima centaurei
(c) aldebaran (d) sirius

2. Write short Answers.

(i) What is a galaxy? What are its main types?
(ii) Describe the birth and death of a star.
(iii) Describe the formation of a neutron star.
(iv) What is the advantage of putting telescope in space?
(v) What does GPS stand for?
(vi) What is the device that make far away objects appear closer to see its detail?
(vii) Describe the various benefits generated by technology of space exploration.
(viii) What is a space probe? Name at least two space probes.
(ix) What is the main differences between an optical telescope and a radio-telescope?
(x) What is space station? Write its benefits.
(xi) What is a black hole? Can it be seen?

3. Constructed response questions

(i) What are advantages of space telescopes such as Hubble and James Webb over the giant telescopes on the Earth's surface.
(ii) What are the problems faced by the Astronauts on space missions? How do they overcome these problems?
(iii) What is gravity free environment? How can it be achieved?
(iv) Why cannot we see the heavenly object "black hole" directly by any telescope?
(v) Comment one public opinion that; "Huge spending on space exploration is extravaganza".

Projects:

1. Teacher may arrange a telescope and help students to view sky on some clear night. Even a medium size telescope can view you fascinating moons of Jupiter and Saturn. The next day students should comment on their telescopic view of the night sky.
2. Library and Internet research: The students should browse Internet / Smart phone or find out article on advancement in space exploration in newspaper and magazines. They should prepare a small presentation to share with class.

GLOSSARY

Absorption of light: Absorption and conversion of light into heat energy.

Acid: A compound which produces hydrogen ion(H^+) in its aqueous solution.

Addition reaction: A chemical combination of two or more substances to form one compound.

Alkali: A compound which produces hydroxide ions in its aqueous solution.

Angle of incidence: Angle between incident ray and normal.

Angle of reflection: Angle between reflected ray and normal.

Axon: A long projection of the cell body which conducts message from the cell body.

Base: A compound which produces hydroxide ions (OH^-) in its aqueous solution.

Black Holes: Massive and dense objects in the space.

Bioplastic: A substitute of plastic.

Biotechnology: A technology which uses living cells and organisms in products and processes that can improve the quality of life.

Concave Mirror: A mirror whose inner curved surface is reflecting.

Cell body: Part of Neuron containing nucleus and most of the cytoplasm.

Cell division: A process in which a cell divides into two daughter cells.

Cerebrum: Top most and the largest part of the brain.

Chemical Equation: Representation of a chemical reaction in terms of symbols, formula and signs.

Chemical Reaction: A reaction in which atoms present in different substances rearrange substances rearrange themselves to form new substances.

Chromosomes: Thread like structures found in the nucleus of a cell.

Circuit breaker: An automatic switch in an electric circuit having function similar to that of a fuse.

Cloning: Biotechnological technique used in various types of genetic analysis.

Commensalism: Type of symbiosis in which one species gets benefit while the other species is neither benefited nor harmed.

Covalent Bond: Bond formed between two atoms of same or different elements by mutual sharing of electron or electrons.

Convex mirror: A mirror whose outer curved surface is reflecting.

Cranial nerves: Nerves arising from the brain.

Cytokinesis: Division of cytoplasm.

Daughter cells: Cells produced as a rest of cell division.

Decomposition reaction: A chemical change in which a compound splits up into two or more simple substances.

GLOSSARY

Deforestation: Destruction of forests as a result of human activities.

Dendrite: A fine projection of the cell body which receives messages.

Density: Mass per unit volume.

Dispersion of light: Phenomenon of splitting light into its component colors.

Detergent: A sodium or potassium salt of long chain fatty acids.

Earth Wire: A wire that connects electric circuits to the Earth.

Ecological Pyramid: A diagram that takes the shape of a pyramid.

Effector: A body part which receives message from brain or spinal cord and produces response.

Electric Circuit: Path along which electric charge flows.

Electric Current: Rate of flow of charge.

Electric power: Rate at which a device converts electrical energy into other form of energy.

Element: A substance which cannot be split into two or more substances by ordinary chemical changes.

Endothermic reaction: A chemical change during which heat is absorbed.

Environmental variations: Variations which are caused by environmental influence.

Exothermic Reaction: A chemical change during which heat is evolved.

Fermentation: A catabolic process in which partial degradation of sugar occurs without the help of oxygen.

Food Chain: Feeding relationship among organisms at different trophic levels.

Food Web: Feeding relationships or interactions between different organisms.

Fore brain: Largest part of the brain.

Fuse: A safety device connected in electrical circuits that interrupts flow of excessive electric current to prevent from damage by over heating or fire.

Gene: Basic unit of heredity.

Genetics: The science of heredity.

Genetic Modification: Removal, addition or repair of genetic material.

Genetically modified bacterium: Bacterium which takes in the recombinant DNA.

Genetically modified Organism: Organism whose genes are modified.

Gene testing: Biotechnological technique used for genetic diagnosis of inherited diseases.

Gene Therapy: Biotechnological technique used to cure genetic and acquired diseases.

Genetic Variations: Variations which arise due to change in genes.

GLOSSARY

Global warming: An increase in average temperature of the Earth.

Groups: Vertical columns in periodic table.

Heredity: Transmission of characters from parents to offspring.

Hydraulics: Branch of science which deals with the transmission of pressured liquids through pipes as source of mechanical force.

Hypothalamus: Part of brain that controls body temperature, hunger and thirst.

Ionic bond: Bond formed by the complete transfer of electron or electrons from one atom to the other atom.

Incident ray: Ray of light that strikes the reflecting surface.

Indicator: A substance that shows different colours in acidic and basic solutions.

Interspecific competition: Competition between different species.

Inter-neurons: Neurons that form a link between sensory and motor neurons.

Intraspecific competition: Competition among individuals within a population.

Medulla Oblongata: Part of brain that controls heartbeat, breathing and digestion.

Meiosis: Nuclear division during which the number of chromosomes in the daughter nuclear reduces to half as compared to that in the parent cell nucleus.

Mid brain: Part of brain that receives information from sense organs and passes to fore brain.

Mineral acids: Acids obtained from minerals.

Mitosis: Nuclear division during which the number of chromosomes in the daughter nuclei remains the same as that in the parent cell nucleus.

Motor Neurons: Neurons that carry nerve impulses from central nervous system to effectors.

Mutation: A change in the genetic material (genes).

Nerve impulses: Messages transmitted by neurons in the form of electrochemical waves.

Neuron: Basic structure and functional unit of the nervous system.

Neutralization: Chemical reaction of an acid with a base to form salt and water.

Nuclear division: Division of nucleus.

Ozone: A layer of gas in the upper atmosphere of the Earth that stops the ultraviolet rays coming from the sun to the Earth.

Ozone depletion: Decrease in the concentration of ozone in the atmosphere due to certain pollutant gases.

Periscope: Optical instrument used to see objects which are higher than our eyes.

Periods: Horizontal rows in periodic table.

Periodic table: Tabular display of the chemical elements.

GLOSSARY

pH: Negative logarithm of hydrogen ion concentration.

pH meter: Instrument used to measure the exact pH of the solution.

pH scale: Scale used to measure the strength of acidic or alkaline solution.

Plane mirror: A smooth flat reflecting surface made up of sheet of glass with a shiny metallic coating on the back.

Plasmids: Additional circular pieces of DNA in the cytoplasm.

Pons: Oval structure of brain that controls sleep, swallowing, equilibrium and taste.

Predators: Consumers that actively hunt other organisms.

Pressure: Force per unit area.

Prey: Organisms upon which a predator feeds.

Reflected ray: Ray of light that bounces off after striking.

Reflection of Light: Bouncing back off light from a smooth shiny surface.

Reflex action: An immediate and involuntary response to a stimulus.

Refraction: The change in direction of light when it enters from one medium to another.

Resistance: Ratio of the voltage across a conductor and the current flowing through it.

Salt: A compound formed by the reaction of an acid with a base / alkali.

Saponification: Chemical reaction of making soap.

Sensory neurons: Neurons that carry nerve impulses from receptors to CNS.

Space exploration: Scientific study of the space using especially developed technology.

Space probe: A vehicle designed to travel in outer space.

Spherical Mirror: A mirror having the shape of a piece cut out of a spherical surface.

Spinal nerves: Nerves arising from spinal cord.

Stimulus: Environmental change that provokes a response in the body.

Symbiosis: A relationship where two species live together closely.

Telescope: An instrument used to see far objects.

Thalamus: Part of forebrain that controls many sensory functions.

Transmission of light: Passing of light after falling on transparent objects.

Tropic Levels: Different feeding levels of organisms in an ecosystem.

Vaccines: A material containing weakened or killed pathogens used to produce immunity against a disease.

Virtual image: Image that cannot be obtained on the screen.

Voltmeter: Instrument used to measure voltage.